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INTERACT

SYMPOSIUM PROCEEDINGS HELD AT CINCINNATI, OHIO ON
11-12 DECEMBER 1972

NATIONAL ENVIRONMENTAL RESEARCH CENTER

JULY 1973

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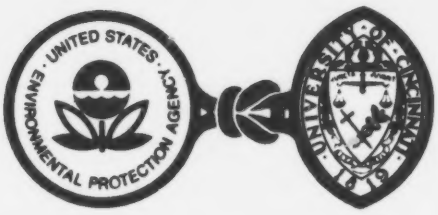
INTERACT

Symposium Proceedings



December 11-12, 1972
Cincinnati, Ohio

National Environmental Research Center, Cincinnati
July 1973

PREFACE

Review of the many contributions to the present volume illustrates the scope of common interests at UC and NERC. This justifies the faith of those who worked so tirelessly over many years to make NERC our neighbor, and who since that time have built up a growing cooperation between our two institutions. I was pleased to participate in the symposium INTERACT, and now to contribute this forward to the proceedings.

Of course, the role and the functions of UC and NERC do and will continue to differ. What impresses me as President of UC is the way in which we can complement one another. This will become all the more important as in the coming years we at UC strive to fulfill the ideal of an Urban University, a University which is not only in the city but also of the city. There is little doubt in my mind that we must continuously cultivate our awareness of the needs especially of urban society. The close proximity of NERC gives UC a great opportunity to grow in this direction and to contribute to the solution of some of the major problems facing us today. At the same time, of course, cooperation can only succeed if it is based on the enlightened self-interest of both parties; this volume shows that UC has much to offer to NERC. On that basis I am confident of the success of our cooperation in the future.

Warren Bennis

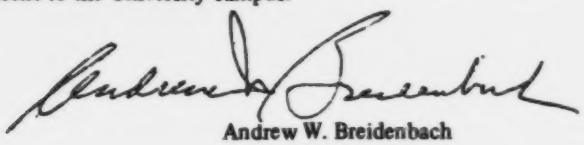
Warren Bennis
President
University of Cincinnati

PREFACE

On April 10, 1972, the University of Cincinnati and the National Environmental Research Center consummated an agreement designed to bring these two institutions closer together. I share with Dr. Bennis the conviction of mutual benefit that will derive for this Center and for the University from the closer ties that will develop.

INTERACT was a major first step in implementation of this agreement. It was intended to bring together the senior staffs of the National Environmental Research Center and of the University so that they might seek and find and explore cooperatively boulevards for common endeavor. INTERACT was a success. More than 100 scientists and engineers went to the podium. Many more made time to listen. But, INTERACT was a beginning, not an ending. The limited interactions between the University and the National Environmental Research Center have already begun to expand.

In the time between now and 1975, we of NERC will look to greater interaction with the University – greater interaction that will form the base for the much closer relationship we envision between our two institutions when the new National Environmental Research Center complex is completed adjacent to the University campus.



Andrew W. Breidenbach
Director
National Environmental Research Center, Cincinnati

Symposium INTERACT

UNIVERSITY OF CINCINNATI | **NATIONAL ENVIRONMENTAL RESEARCH CENTER**

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CONTENTS

Introduction	1
Behavioral Sciences	3
Biology	9
Chemistry-1	15
Chemistry-2	19
Chemistry-3	25
Disposal of Wastes	31
Earth Sciences	37
Economics	43
Education	49
Enforcement	57
Environmental Medicine-1	65
Environmental Medicine-2	71
Mathematics	77
Microbiology	83

INTRODUCTION

Symposium INTERACT took place on December 11 and 12, 1972 on the campus of the University of Cincinnati.

The symposium was suggested by Dr. I. Leonard Bernstein as an instrument through which the common interests of the professional personnel of the two institutions could be beneficially explored. It was planned by a joint subcommittee of the NERC-UC linking pin committee, appointed by the Director of NERC and the President of UC, as an implementation of the *Statement of Mutual Assent*, an agreement by UC and NERC to seek closer relationships wherever possible. It was implemented by the more than 110 participants who presented the papers and chaired the sessions, and the many more who attended and participated in the debates.

The symposium brought together professionals from a wide variety of disciplines. Each presented his own interests and sometimes those of departments or programs with which he was associated.

Herein are published the epitomes of those presentations to serve as one base for future interactions.

BEHAVIORAL SCIENCES

Session Chairman and Editor

JAMES M. ALEXANDER, JR.

Department of Industrial Design
College of Design, Architecture and Art, UC

Perception and Assessment of the Environment

WOLF RODER, Department of Geography, College of Arts and Sciences, UC

Attitude and Behavior Concepts: Applications to the Environment

RICHARD H. ONGERTH, Behavior Research Systems and Behavior Branch, Solid Wastes Research Laboratory, NERC, EPA

Reality of Cultural Conservation Through Protection of Physical Environment with Citizen Participation

HARRIS N. FORUSZ, Department of Industrial Design, College of Design, Architecture and Art, UC

Wave Model of Population Growth and Redistribution

LAURENCE G. WOLF, Department of Geography, College of Arts and Sciences, UC

Development of Protective Environmental Quality District Legislation for Cincinnati

RICHARD H. WHEELER, Department of Architecture, College of Design, Architecture and Art, UC

Consumer Acceptance of Reused Water

FRANCIS M. MIDDLETON, Deputy Director, NERC, EPA

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BEHAVIORAL SCIENCES

Man's concern for and awareness of his environment is a wellhead for its enrichment. The acuity with which man perceives change and the need for change, and how he reacts to it will determine the civilization level of the society in which he resides.

Roder. Our research on human response to natural and man-made hazards, done in conjunction with the International Geographic Union's man and environment commission and departmental research on environmental perception, addresses itself to the major question, "How do people perceive the environment?" and assumes that environmental action depends on such perception and involves people's evaluation of opportunities, hazards, available technology, public policy guides, and efficacy of action.

Research has focused on coping with hazards, residential environmental choice, recreational environmental preferences, and the roots and sources of environmental perceptions.

General conclusions which have emerged from this research include: 1. Man-made and natural hazards are perceived in much the same way, and consequently the corrective action demanded of public bodies is on the same order and of the same kind. 2. Human perception of the environment is generally at a low level, and rises only when the individual is confronted with stress from the environment. 2a. The corollary: – other perceptions and objectives of the individual have much higher priorities, and his decision-making process is consequently little affected by environmental considerations. 3. Environmental perception is rooted in many sources other than the environment itself. This means that, in part, we have created the "environmental crisis" by public focus on these issues. 4. The department has built up an experiential background in concepts and methods with which we can confront some specific questions in regard to the environment.

These questions about the impact and the perception of the environment must be framed at a wide range of spatial scales. We lack clear visions of ideal environments for man versus the minimum acceptable, except that we do know there is a wide range between the two ends of this spectrum within which we must identify the goals for which we strive.

Ongerth. There are a number of attitude and behavior concept areas in which the National Environmental Research Center, Cincinnati needs greater expertise or access. They included behavior analysis, behavior modification, survey research, educational technics and attitude and opinion formation. These concepts may apply in attaining administrative and public approval for handling, treatment, and disposal facilities, understanding and taking corrective action against the problem of litter and littering, and reducing the consumption of natural resources and the generation of waste products.

A systematic approach is badly needed for insuring administrative and voter approval for location and financing of water, waste water, and solid waste facilities. Currently, optimum designs from an engineering and economic standpoint are being rejected because of unnecessary lack of approval. Some

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progress has been made in this area. Several short education programs have been developed. Unfortunately application of this information has been practically nil because of limited knowledge about their availability.

Litter is recognized more and more as a serious environmental problem with a behavioral rather than a technical solution required. The diversity of materials found in litter makes legislative controls most difficult. Mechanical pickups temporarily eliminate visual contact with litter, but do not solve the problem. The possibility of a combined education and behavior modification approach appears most promising in this area.

Far too little attention has been given to non-technical approaches to controlling water consumption, waste water, and solid waste production. This is a wide-open field where education, attitude, and behavior modification should find significant application with a high probability for meaningful accomplishments.

Behavioral solutions in the traditionally technology oriented environmental field have been overlooked in the past. Blame for this oversight rests not only on technical personnel, but also on behavioral science academicians for not stressing broad enough application of their skills. Now is the time to correct this situation, when the general public has the necessary high interest and concern for environmental quality.

Forusz. A study based on five premises was undertaken in the Findlay Market area (1/6th of the Over-the-Rhine area).

The premises were that there exist in this area: 1. different perceptions of the realities of different groups, 2. different cultural values, 3. a multi-varied physical environment, 4. neighborhood indicators, and 5. citizen participation at a multitude of levels.

In approaching the problem this way, we did not come up with answers, but did learn some lessons which can be used by others in approaching similar problems: 1. It is imperative that observation and identification of sources of cultural norms for each particular group within a neighborhood be made before any action is started. (Identify as many users as possible). 2. Attempts should be made to identify all the hidden agenda as well as those that are presented and changed because of specific action. 3. By being given a mandate by a particular group for a particular action, one is also given access to far more resources than at first seems apparent. This allows one to set up alternatives to respond to inadequacies in the given program. 4. Present clear information to all concerned groups beforehand on the range of choices that are available in terms of committed and accessible resources so that the communities can truly participate and hopefully have control over allocation decisions. 5. Present to each community physical environment alternative layouts and changes possible within the context of the existing styles of the physical environment that respond to that community's specific socio-demographic character. 6. Build into each of the communities a basic supply of macroservices (before redevelopment plans are generated) with knowledgeable people well versed in the cultural values of the various socio-economic groups and who have some real control over, and real understanding of, resource allocation to the groups that they are to serve. 7. Through preparatory dialogue and interaction with communities, develop a sense of the collective community consciousness so that one can prevent the appalling redundancy evident in many planned environments where physical facilities have been provided by the power

structure to fit the conventional planning model of fitting population into an environment prefabricated on the power structure's perception of reality.

Wolf. The focus of our concern is the modern American metropolis as a population-redistributing system. Each metropolis is, among other things, an outward-moving spatial system, at the center of which population growth is negative, and near the periphery of which there is an irregularly shaped ring of high growth rates.

Seen in profile, this takes the form of a wave, which has been divided into four portions for purposes of analysis: 1. a paleo-urban zone of population decline, 2. a meso-urban zone of moderate growth, which, historically, is approaching paleo conditions, 3. a neo-urban zone of peak growth rates, and 4. a peri-urban zone of moderate but accelerating growth rates which presage the arrival of neo-urban conditions at some future date.

Casting geographical population data for a series of decades into this sort of spatial schema accomplishes several desiderata: 1. the metropolis is viewed as a whole thus avoiding the widely-used but fallacious city/suburb dichotomy, 2. it is a dynamic instead of a static areal classification, 3. it derives a general conceptualization from the empirical data instead of forcing the data into a preconceived and arbitrary format, 4. it enables one to identify not only a general rate of expansion but also the detailed pattern of that expansion, and 5. it emphasizes the historical continuity of geographic metropolitan growth patterns.

The magnitude of the populations we are considering can be indicated briefly as follows, using the state of Ohio as a case study:

I. The Four Metropolitan "Tidal Wave" Regions of Ohio, as of 1960:	
The Northeastern Conurbation:	3,730,500
The Miami Valley Conurbation:	2,021,500
The Columbus Region:	902,400
The Toledo Region:	520,000
Total:	7,174,400

II. Totals for the four zones of the waves, taking the four regions as a unit:	
Paleo-urban	1,554,800
Meso-urban	2,231,000
Neo-urban	2,434,200
Peri-urban	954,400
Total:	7,174,400

Holding the zones constant in space as of 1960, in order to develop a forecast, we found that 74 percent of the population of Ohio was contained within these zones in 1960 and that approximately 82 percent could be expected within these zones by the year 2000.

Wheeler. Two important pieces of proposed legislation are before the Urban Development Committee of the Cincinnati City Council. These would amend the Cincinnati Zoning Code and are titled *EQ (Environmental Quality) District Regulations and HP (Historic Protection) District Regulations.*

The EQ District Regulations are the subject of a great deal of local discussion. According to Mr. Gale Brooks, Environmental Preservationist,

"The principle objective of the Proposed Protection District Regulations

is to provide a method of guiding development and protecting the existing environment in defined districts of the city. The proposed regulations are not intended to prevent change; they have been designed to avoid the possibility of a person or group, knowingly or unknowingly, acting irresponsibly in such a manner as to precipitate change to the existing environment which would be detrimental to the general public interest. The method proposed would use the established legal power and regulatory procedures of zoning. For this reason, the proposed regulations are in the form of a Text Amendment to the Cincinnati Zoning Code. The Text Amendment as proposed would centralize and incorporate two existing protection ordinances into the Zoning Code and add Fountain Square as an additional district."

We are where we are, after more than two years of work. The work was not begun in response to any recent proposed developments in Cincinnati. It was initiated as a medium range goal to encourage and to guide future physical development of Cincinnati in the same way that previous redevelopment in the central business district has been successfully guided.

The desire is for a quality physical environment. The desire is to encourage change with continuity of environmental character. The method is one way in which it can be achieved. It seems a logical way. In the eyes of legal consultants it is a constitutional way. In the eyes of many more Cincinnati citizens, it is a necessary way if Cincinnati is to continue to build in a humane manner.

Middleton. All of our waters are reused. The relatively fixed supply of water on earth changes but little. Most reuse is a part of the natural evaporation - precipitation cycle. Pathways of reuse are now becoming more direct and waste-contaminated waters have become a source of part of our potable water supplies. In most cases, the waste waters are diluted by the natural waters in rivers or lakes. In the drier parts of the world such as Israel and South Africa, waste waters are looked upon as an important water source for all purposes. Careful waste water management and treatment makes it possible to reuse waste waters for at least a portion of drinking water supplies.

Health protection is paramount when direct recycle is practiced. Even if direct waste water renovation and reuse is perfectly safe it must be accepted by the consumer. Public education and appropriate consumer surveys must be accomplished. In Windhoek, Southwest Africa, it was necessary to treat and use waste waters for one-third of the potable supply. Public education, open plant visitation and endorsement by high public officials was effective, and the situation was accepted by the consumers without complaint. The City of Denver, anticipating waste water reuse in the future, has had a favorable response from the citizens indicating strong faith in the water utility to do the proper thing. In California, public opinion surveys on use of reclaimed waters have shown mixed results but indicate most citizens are not ready to accept renovated waters for drinking. Other uses, such as for irrigation and recreational lakes, are accepted. The Environmental Protection Agency has a policy encouraging appropriate reuse of waste waters, but not for direct recycle to potable supplies.

Wastewater reuse is a fact of life now. The degree and directness of such reuse will increase. Technical accomplishments and an informed public will bring reuse to its full value in future years.

BIOLOGY

Session Chairman and Editor

HARRY RUDNEY

Department of Biological Chemistry
College of Medicine, UC

Long Term Laboratory and Field Fish Toxicity Testing

WILLIAM B. HORNING, Newtown Fish Toxicology Laboratory, NERC, Corvallis, EPA,

Physiological Responses of Fish to Temperatures Near Freezing

BRUCE L. UMMINGER, Department of Biological Sciences, College of Arts and Sciences, UC

Biological Methods Research in the Aquatic Environment

CORNELIUS I. WEBER, Biological Methods, Analytical Quality Control Laboratory, NERC, EPA

Cultured Mammalian Cells as a Biological Test System for Environmental Agents

ROBERT T. CHRISTIAN, Department of Environmental Health, College of Medicine, UC

Aquatic Organisms in Enforcement of Water Quality Standards

ERNEST G. KARVELLIS, National Field Investigations Center-Cincinnati, Office of Enforcement and General Counsel, EPA

Biological Model for Studying the Pulmonary Effects of Chemical Contaminants

RICHARD W. NIEMEIER and EULA BINGHAM, Department of Environmental Health, College of Medicine, UC

Proteolytic Enzymes in the Environment–Methods for Quantification

LESLIE W. MICHAEL, Department of Environmental Health, College of Medicine, UC

BIOLOGY

Biological systems may pose serious threats to the environment; others may be used as pollutant detectors. A variety of potential environmental hazards in the air and water may be monitored by biological means.

Horning. The Newtown Fish Toxicology Laboratory is an EPA field station under the direction of the National Water Quality Control Laboratory in Duluth, Minnesota. Its basic mission is to develop the water quality criteria necessary to support aquatic life. Once developed, the criteria may be used as a basis for establishing effluent standards.

The work at Newtown is primarily concerned with testing the toxicity of various substances to fish. This is done by utilizing short-term acute toxicity tests and sublethal (chronic) toxicity tests which are designed to measure the long-term effects of toxicants on the growth, survival, and reproduction of test animals. Presently, such tests are among the main tools for determining water quality criteria.

One of the major activities at the Newtown facility centers around the Shayler Run copper toxicity study, a field study carried out under essentially natural conditions (in contrast to a laboratory study carried out under fully controlled conditions). The study is intended to determine whether laboratory derived fish toxicity data are applicable to the natural environment. Copper is added to an isolated section of Shayler Run Creek in direct proportion to stream flow, to maintain a copper concentration of 120 ppb. The primary effects under study are those affecting growth, reproduction, and survival of the fish in the stream. Secondary effects of copper on fish and other aquatic biota in the stream are also examined to gain a better understanding of overall ecological impact.

Work dealing with chronic effects of cadmium and nickel, and work on the effects of trivalent and hexavalent chromium on the fathead minnow has been completed. This study is now being extended to bluegills.

Future work will be directed toward developing technics for monitoring complex and variable waste effluents using aquatic organisms. Our ultimate goal is to generate data that will assist us in establishing effluent standards for protecting waters receiving complex industrial and muncipal waste effluents.

Umminger. Exposure of the salt-water-adapted killifish, *Fundulus heteroclitus,* to subzero temperatures elicits a marked hyperglycemia which persists for several weeks. This cold-induced hyperglycemia results from a breakdown of hepatic glycogen produced by an increase in the specific activity of hepatic glycogen phosphorylase. The hormonal regulation of this response is not under pituitary control and presumably results from a hypertrophy of glucagon-producing alpha cells and an atrophy of insulin-producing beta cells in the pancreatic islets. Serum glucose is not maintained at high levels indefinitely, but begins to drop when hepatic glycogen is depleted. The fish begin to die when serum glucose levels fall to normal, but addition of glucose to the water elevates serum glucose levels and enhances survival. The elevation of serum glucose in the subzero cold is an adaptive response permitting survival

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in a supercooled state, presumably by retarding ice crystal growth on any ice nuclei that might form spontaneously in the blood.

Ionic regulation is also impaired in the euryhaline killifish at low temperatures. In salt water, acclimation to subzero temperatures is accompanied by an increase in the concentrations of serum sodium and chloride whereas, in fresh water, low temperature causes a decline in serum electrolyte levels. Such alterations in serum electrolyte concentrations are characteristic of all teleosts, both marine and freshwater, when acclimated to low temperatures.

Weber. The Biological Methods Section of the Analytical Quality Control Laboratory develops and evaluates field and laboratory methods to detect violations of water quality standards, measures the effects of effluents on natural communities of aquatic organisms, and determines long-term water quality trends.

Water quality is reflected in the abundance, taxonomic composition, and diversity, and in the condition of plankton, periphyton, macrophyton, macroinvertebrates, and fish. Field methodology research, therefore, deals with optimization of sampling frequence; sampling devices; sample processing, storage and preservation; enumeration and identification of organisms; measurement of biomass and metabolic rates; and effluent biomonitoring. Methods are also developed for laboratory studies of environmental requirements of aquatic organisms, effects of toxic industrial and domestic effluents on individual species and communities of organisms, and the transfer and accumulation of hazardous substances in aquatic food-chain organisms and commercially-important species.

The program is carried out by two research teams, a Plankton Periphyton Group and a Benthos (macroinvertebrate) Group. Current research on plankton methodology includes the evaluation of ATP as a measure of total viable biomass, and studies of phytoplankton pigment extraction, identification, quantification and stability. Periphyton methodology projects include an evaluation of parameters such as cell density, biomass, species composition and diversity, organic matter: chlorophyll *a* ratio and pigment composition, potentially useful in measuring the effects of toxic industrial wastes on natural periphyton communities. Macroinvertebrate projects include an evaluation of the usefulness of macroinvertebrate drift in water quality studies, comparison of the performance of bottom grab samplers, and studies of the effects of sampler geometry, depth of exposure, and length of exposure time on the abundance and species composition of the samples. An agency biological methods manual is in preparation and will be available early in 1973.

Christian. Cultured mammalian cells may serve as a biological test system for environmental agents such as metals (both essential and toxic), radiation, coal dust, and raw water.

The cell is an appropriate test model because it is the smallest living organized unit of the mammalian organism containing the basic metabolic processes and their control mechanisms. The system is quite sensitive because toxic substance can be used to make up essentially all of the cell's environment and three or four generations of cells can be studied in one week. There are, however, definite limits to this sensitivity.

Coal dust and coal dust extracts inhibit the growth of cultured cells. An

investigation was made to determine whether a substance in coal dust or the physical coal dust particle itself is the etiological agent of coal worker's pneumoconiosis (CWP or Black Lung Disease). The coal dust (1 percent w/v) was extracted with water, calf serum, and cell culture medium, and growth inhibition was found to correspond to the evidence of CWP observed in the areas where the coal was mined. Inhibition was greater with coal mined in Pennsylvania, a high CWP area, than with coal mined in Utah, a low CWP area. Growth inhibition was dose-dependent and linear from undiluted to a 1/100 dilution of these extracts. Chemical fractionation of the coal dust removed most of the growth inhibitory substances. Other environmental agents are under study with the same technics.

Karvellis. The Biology Section of EPA'S National Field Investigations Center-Cincinnati (NFIC-C) is responsible for gathering data for enforcement of water quality standards. The time available for gathering such information is usually limited, necessitating the application of technics that will produce maximum amounts of data quickly.

The NFIC-C biologists depend upon organizations such as NERC, Cincinnati, and the universities to develop the methodology of enforcement. Field sampling technics for benthic, sediment, and plankton are research areas that need attention. Bioassays also need attention, and a better understanding is needed of physiological changes that occur in the aquatic biota as water quality of an area is altered.

Niemeier, Bingham. Isolated perfused lung preparation may serve as a biological model for studying the pulmonary affects of chemical contaminants in the environment.

Such preparations offer great potential in studying the distribution, binding, rates, and pathways of metabolism of foreign compounds under conditions closely resembling those which occur in living animals. Lungs from either normal or perfused animals may be investigated. Criteria have been developed that are necessary to insure viability and provide optimum conditions for metabolic studies.

Michael. Methods are being developed for the quantification of proteolytic enzymes in the environment.

The proteolytic enzymes under investigation are those isolated from *Bacillus subtilis.* These alkaline proteases, or subtilisins, are the enzymes used in cleaning products such as detergents, pre-soaks, bluing, and drain cleaners.

The level of control proposed for industrial environments is 0.3 micrograms of pure enzyme per cubic meter. This is the current Threshold Limit Value (TLV) recommended by the American Conference of Governmental Industrial Hygienists. This value is doubly unique. It is the smallest of the TLV's cited, and the control level is expressed in terms of activity of the enzyme in gravimetric units. The analytical task of quantitating proteolytic enzymes is therefore twofold: a. methodology must be provided for the determination of proteolytic enzymes in the industrial atmosphere at these levels, and b. a capability must be developed for expressing the levels assessed in terms of pure or active enzyme.

The *trans*-cinnamoylimidazole acylation reaction has been applied to the measurement of proteolytic enzyme activity by determination of hydrolysis and quantitation of the hydrolytic product.

CHEMISTRY—1

Session Chairman and Editor

DWIGHT G. BALLINGER
Analytical Quality Control Laboratory
NERC, EPA

Colloids in Wastes

ROBERT B. DEAN, Ultimate Disposal Research Program, Advanced Waste Treatment Research Laboratory, NERC, EPA

Determination of Radioactive Phosphorus in Aqueous Samples

G. DOUGLAS WINGET, Department of Biological Sciences, College of Arts and Sciences, UC

Permeation Tubes as Standard Gas Sources

WILLIAM R. BURG, Department of Environmental Health, College of Medicine, UC

Comparative Biochemical Effects of Alkylmetals in Aqueous Solution

JOHN S. THAYER, Department of Chemistry, College of Arts and Sciences, UC

Laser Phosphorimeter-Computer Interface

R. MARSHALL WILSON, Department of Chemistry, College of Arts and Sciences, UC

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CHEMISTRY-1

The substances that constitute society's wastes require definition if their impact on health is to be assessed. An understanding of the nature of these substances and their interreaction with the environment depends upon the development of new methods and the application or adaptation of some already available.

Dean. The separation of solids from water by gravity or filtration is difficult when the particles are in the colloidal or super colloidal range. However, rapid removal of soluble foods requires large surface areas. Area can be economically provided by small organisms in the range of one μm.

Flocculation of colloidal particles and microorganisms produces loose structures several millimeters across which will settle out leaving a fairly clean effluent. Flocculation involves physical attachment of particles or electrostatic equilibria. In waste water physical attachment dominates and electrokinetic potentials play a very limited role because of the high concentration of soluble salts (about 10 millimoles) including divalent ions of both signs.

Flocculating agents which combine particles by physical attachment include hydroxides of Fe^{+3}, Al^{+3}, and Mg^{+2}, organic polymer flocculants such as polyacrylamides and natural polysaccharides produced by bacteria. The latter substances are responsible for the operation of biological treatment of waste waters. Bacteria which form flocs or attach themselves in slime coatings on fixed media are selectively cultivated and reused to remove organic foods (Biochemical Oxygen Demand or BOD) from waste water.

Flocs have low densities since they are loose aggregates containing mostly water. A typical settled activated sludge contains 100 kg of water per kg of solids. Removal of water from biological flocs is one of the most expensive unit operations of sewage treatment.

Soluble organic wastes are adsorbed on activated carbon which has colloidal dimensions. Powdered carbon adsorbs rapidly, but must be removed by flocculation. Granular carbon with a radius of about one millimeter adsorbs more slowly but can be used in fixed bed reactors. Thermal regeneration gives as completely satisfactory ultimate disposal of organic matter as it does of CO_2, H_2O, and N_2.

Winget. In aqueous solution, the high-energy β-decay of phosphorus-32 causes light emissions, referred to as Cerenkov radiation. The light produced can be detected in a scintillation spectrometer, and the number of light flashes can be related to the amount of phosphorus in the solution.

An investigation has been carried out to determine the effect of various substances that might interfere with the light production or reduce the light yield. Interfering substances have been identified and some of the precautions necessary for the successful use of this method for quantitative assays have been determined.

Burg. Calibration standards are essential for reliable environmental measurements. Available standard reference materials are especially lacking in air quality monitoring programs.

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However, permeation tubes have recently been developed as convenient sources of gases for preparing known low concentrations in air for calibration of instruments, development and testing of analytical methods, and for toxicological studies. Liquified gases such as sulfur dioxide, nitrogen dioxide, hydrocarbons, hydrogen sulfide, and hydrogen fluoride sealed in teflon tubing permeate through the walls at nearly constant rates.

The rate of permeation, in the order of nanogram quantities, is highly temperature dependent but relatively independent of flow rates and pressure changes in the atmosphere. Individual tube permeation rates can be accurately calibrated by gravimetric volumetric technics to serve as standard gas sources.

The lifetime of a permeation tube can be extended to over a year by attaching a reservoir.

Thayer. Current interest in heavy metals in the aquatic environment has been precipitated by the mercury crisis. The recent reports of poisoning by methylmercury compounds represent the third such occurrence of widespread mortality through unintentional ingestion of alkyl metals.

Alkyl compounds of tin, lead, and thallium strongly resemble the corresponding alkylmercurials in their chemistry. In view of this, and because alkyltin and alkyllead species are also known to be toxic, we recently inaugurated a series of comparative studies on the biological effects of these compounds as a function of metal, alkyl group, and concentration.

Cucumber seeds were grown in a gel of polyvinylpyrrolidinone and distilled water. Sprouting proceeded normally, and the seedlings were transplanted to soil. When aqueous solutions of alkylmetals were used in the gels, abnormal development occurred. No viable seedlings formed at concentrations higher than one mg alkylmetal per liter of water; instead, radicle development was retarded, and off-white cotyledons emerged. At lower concentrations, more normal development occurred, but at appreciably slower rates in the controls.

The methyl compounds of thallium and lead showed greater effect than those of mercury or tin. In the trialkyllead series, the effects varied $C_2H_5 > CH_3 > C_3H_7 \sim C_4H_9$.

First experiments on the effects of alkylmetal solutions on *Daphnia magna* indicate that concentrations of 50 mg per liter or higher are fatal, that there is a concentration dependence, and that mercury is more potent than lead.

Wilson. The analyses of phosphorescence spectra are often complicated by the superposition of the emission from several excited species. This is particularly a problem when examining the emission from a mixture of substances.

In order to circumvent these difficulties, a computerized laser emission spectrometer was developed which resolves a complex phosphorescence spectrum into the spectra of the pure emitting components. These pure component spectra are generated on a Calcomp plotter from decay data acquired at many wavelengths and, with the aid of a computer, resolved into first order components.

CHEMISTRY—2

Session Chairman and Editor

GEORGE DAHLGREN
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College of Arts and Sciences, UC

The Nitrogen and Phosphorus Problems in the Water Environment

EDWIN F. BARTH, Biological Treatment Research Program, Advanced Waste Treatment Research Laboratory, NERC, EPA

Immobilized Enzymes in Water and Wastewater Treatment

JAMES D. OGLE, Department of Biological Chemistry, College of Medicine, UC

Carbon Adsorption in the Treatment Process

IRWIN J. KUGELMAN, Physical and Chemical Treatment Research Program, Advanced Waste Treatment Research Laboratory, NERC, EPA

Optimization of Carbon as an Adsorbent

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Removal of Ions in Solution by Reverse Osmosis, Ion Exchange, and Electrodialysis

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Ultrafine Materials for Reverse Osmosis

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Coagulation-Flocculation Processes

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CHEMISTRY-2

Removal of contaminants from waste water in the process of converting such water to acceptable quality for discharge or reuse is largely a physical-chemical process.

Barth. Over the past 75 years, waste water treatment has concerned primarily the single chemical element carbon in its various organic forms. With the intense urban, suburban, and cultural growth that has occurred in the last decade there now exists the need to control the various forms of the elements phosphorus and nitrogen, phosphorus compounds because of their associative role in eutrophication of impounded waters, and nitrogenous compounds because of their environmental, health, and eutrophication effects.

Research, development, and demonstration programs have brought to fruition a number of processes which can be applied at municipal facilities for the control of the carbonaceous, nitrogenous, and phosphatic residuals of effluents. In a large measure, developmental progress has been along the lines of chemical engineering and unit process operation.

By proper control of chemical dosing for insolubilization and coagulation, on a mole ratio basis, and provision for proper clarifier overflow rates, phosphorus removal can be instituted at any existing treatment plant. An effluent phosphorus residual of 1 mg per liter can be affected with minimum capital cost. To obtain effluent residuals of less than 1 mg per liter consistently would require greater capital cost because of the need for filtration and provision for chemicals for polish dosing.

The present technology for control of nitrogenous materials is oriented to the design of staged biological systems for nitrification or subsequent biological systems for nitrification or subsequent biological denitrification. The staging of these systems allows engineering control of the biological transformations necessary for high efficiency in a sequential process. Nitrification processes require a 10 to 15 percent capital cost increase over conventional design for BOD_5 and suspended solids removal. Nitrogen removal processes utilizing biological denitrification require a 25 to 30 percent increase in capital cost over conventional design. Nitrogenous residuals of 1.5 to 2 mg per liter can be obtained when these staged systems are applied to municipal waste waters.

Comparable comprehensive developmental work has yet to be applied to the control of nitrogenous and phosphatic residuals in industrial effluents.

Ogle. Enzyme-organic polymer complexes attached to glass surfaces may be used in the treatment of water for decomposing or modifying undesirable substances which are currently handled by biological – or adsorbent – filtration processes. However, when enzymes are attached to insoluble macromolecular supports, they often undergo some undesirable changes in properties such as pH optimum and specificity and relative activity toward large and small molecular weight substrates.

We have compared the properties of an immobilized enzyme with those of the native form in solution. We immobilized trypsin on a matrix of aminoethyl cellulose by the use of glutaraldehyde as a bridging agent. More trypsin could be attached to this matrix than is generally realized with other supports. The

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immobilized enzyme retained 100 percent of its native activity towards small synthetic substrates, but possessed only 10 to 20 percent of its original activity toward protein substrates and protein inhibitors, thus demonstrating a large steric hindrance effect. The pH optimum shifted slightly to higher values for small substrates, but there was no change toward protein substrates. The immobilized form of the enzyme was stable at room temperature and resisted the autolysis usually associated with proteolytic enzymes in solution.

The use of diamine spacers to attach the enzyme further away from the matrix and thus increase its activity toward the larger substrates is now being studied. Comparison with other enzymes shows that each enzyme upon immobilization is a unique case and must be studied individually.

Kugelman. Early work established the value of activated carbon for treatment of biologically-treated waste water. Recent work established the utility of this process for treatment of chemically clarified waste water (i.e., physical-chemical treatment). Granular carbon contacting systems have been demonstrated in pilot and full scale (Lake Tahoe, 7.5 mgd). The basic engineering of granular carbon systems has been developed but improvements in regeneration technic, contacting schemes, and economics need to be made. A major unresolved area is the optimum method for utilizing biological activity which occurs on the carbon particles. The biological activity enhances the carbon capacity, but produces increased rates of pressure drop buildup in packed beds and fosters sulfide production. A second area where engineering research is required is in development of improved regeneration technics. Present thermal regeneration in a multiple hearth furnace is satisfactory, but applicability of the process would expand if *in situ* regeneration technics, either chemical or thermal, were developed.

The feasibility of powdered carbon contacting has been demonstrated at 100,000 gpd and now requires only demonstration on a larger scale. Regeneration of powdered carbon has been successful at only small pilot-scale. Additional work on furnace design and operation is required to provide powdered carbon regeneration with an acceptable loss rate. Sulfide control with this contacting mode also needs attention.

The use of throw-away carbon (once-used carbon) is still an unexplored area. The concept best fits small plants where the capital and labor expenditures of present regeneration schemes cannot be justified. Laboratory studies have shown that the char produced from pyrolyzed solid waste can be economically activated and used as an adsorbent on a once-use basis. Screening tests of other chars and pyrolyzed substances should be conducted with a wide variety of sewages to determine whether such materials can serve as once-use adsorbents. In addition, a considerable degree of scale-up is required for methods of applying carbon to waste water and for methods of pyrolyzing and activating various types of raw materials.

Activated carbon is an excellent adsorbent for the broad range of organics which occur in domestic waste water. However, the characteristics that control the performance of activated carbon as an adsorbent are not clearly understood. None of the conventional characterization tests such as iodine number and molasses number correlate well with adsorption performance. It is impossible to predict whether and to what extent any particular organic compound will be removed by contact with activated carbon. Thus, our ability to predict the role of activated carbon in the removal of hazardous materials

from waste water is limited. The role of activated carbon in waste water reuse schemes will require additional knowledge in this area.

The characterization of systems in which activated carbon and microorganisms function simultaneously for organic removal from waste water is another area worth study. Systems now exist which are characterized as activated sludge treatment to which powdered carbon is added. Other systems are in use in which granular carbon apparently plays the primary role and where microbiological activity is an aid in *in situ* regeneration. It is probable that both of these systems have much greater similarities than differences. It would be interesting to develop a unified model which would properly evaluate biological and adsorptive activities in such combined systems.

Mark. Internal Reflectance Spectroscopy (IRS) methods may be used to optimize carbon as an adsorbent. Infrared spectral methods have been developed for functional groups adsorbed on opaque films and surfaces such as activated carbon. This technic gives direct *microscopic* information on the chemical nature of the surface and the adsorbed films.

We have studied the actual surface chemical interactions that take place on adsorption from solution which could only be guessed at from *macroscopic* adsorption isotherm type data. A basic understanding of bonding interactions in chemisorption may predict the surface preparation or activations that optimize the concentrations of the surface functional groups taking part in the chemisorption of a particular species (pollutant).

Cohen. In a single water use, some 100 to 500 mg per liter of total dissolved solids are added to existing minerals in the water supply. Some parts of the country will require at least partial removal of the salts. A typical example, Riverside, California, starts out with 800 to 900 mg per liter TDS in its water supply, ends up with 1,300 mg per liter in its sewage, and must reduce this to 600 mg per liter before the treated sewage can be injected into the ground to mingle with potable water.

Three processes have been researched for demineralization of sewage: reverse osmosis, ion exchange, and electrodialysis. Another process, distillation, is generally considered more applicable to seawater desalting.

Reverse osmosis, the most innovative development of the past 50 years, has not turned out the panacea it appeared to be initially. While potentially the process can remove both organic and inorganic contaminants, in practice this has not been achieved. Membranes have yet to be developed which have the desirable characteristics of high flux, high rejection, long life, and low cost. Fouling of membranes at present can only be controlled by extensive pretreatment of the sewage and by flushing technics. Still, the process has potential merit and research should continue.

Ion exchange is an old, well-developed technology but with a new application to sewage. Fouling by the organics in sewage requires pretreatment and use of newly developed weak anion resins. Thus far, ion exchange appears technically feasible, but general acceptance awaits demonstration of large scale application. A major problem with all demineralization processes is disposal of brine concentrates. In ion exchange, the problem is aggravated by the regeneration chemicals. Prospects for the use of electrodialysis in sewage application appear dim at this time. Membranes are easily fouled, a very high degree of pretreatment is required, and only 35 to 40 percent of salt removal

can be obtained in a single pass.

At present, ion exchange is the least expensive, given the conditions of TDS not in excess of about 1,000 to 1,200 mg per liter, and disposal of brine to the sea or to evaporation ponds. The rising need to augment water supplies will almost surely engender greater research efforts on demineralization of sewage.

Kuhn. Asymetrical membranes made from cellulose acetate and nylon are used currently in the reverse osmosis removal from effluents of salt and other solutes. These membranes may be self-supporting in the form of very fine hollow fibers or supported on a porous substrate made from metallic or ceramic materials.

Four arrangements for supporting reverse osmosis membranes have received the most attention in practical module designs, namely plate and frame, tubular, spiral-wound, and hollow fiber and spiral-wound are most in favor. Tubular systems are, however, still in competiton.

Fine, porous, walled tubes, made by a powder metallurgy technic from very fine powders, are proposed as supports for reverse osmosis and dialysis membranes in the purification of water and biological fluids. Presently, tubes are produced for a prosthetic device that facilitates nerve regeneration in the peripheral nervous system. These tubes have characteristics that would make them useful as membrane supports for compact reverse osmosis and dialysis systems.

Hannah. Small particles in the colloidal size range do not settle out of waste water in a practical detention time. In coagulation-flocculation processes, chemicals are added to destabilize the small particles, and controlled stirring is applied to cause the particles to collide and agglomerate into large particles which settle out of waste water. Organic polyelectrolytes have been extensively evaluated as flocculation aids.

Various methods to control and monitor coagulation-flocculation processes have been investigated by personnel at NERC. The jar test, which attempts to stimulate the full-scale operation is the most commonly used control technic. Other control procedures involve measurement of particle zeta potentials and dosing of coagulant in proportion to waste water phosphate content. Measurement of residual turbidity is the usual method for monitoring results of coagulation-flocculation processes. An empirical light-scattering technic is now available, but a more fundamental procedure is needed to rapidly yield suspended solids content of treated waters.

Present research at NERC on coagulation-flocculation processes deals with precipitation of toxic or otherwise undesirable metals from waste water. Results indicate that the chemistry of each metal as it interacts with each coagulant must be considered.

Because of funding limitations, basic research on solids removal is not supported by EPA at this time. In a number of solids-removal projects, however, novel treatment devices are being optimized. A *Process Design Manual for Suspended Solids Removal* available from the EPA Technology Transfer Program, is being updated to provide the latest available information for removing solids from waste water.

CHEMISTRY—3

Session Chairman and Editor

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Identification of Chemical Constituents in Untreated and Treated Water

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Determination of Organics in the Water Environment

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Application of Instrumentation for Pollutant Analysis

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Automated Analysis

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Biochemistry of Waste water

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Identification of Oil Pollutants

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CHEMISTRY -3

The development of methods for detecting and identifying pollutants in the environment is the first requisite for abatement. It is a difficult task not to be underestimated.

Lingg. Direct water reuse systems are a possible answer to future water shortages and for isolated units where water must be shipped in at great expense. The feasibility of such systems will depend on the development of rapid and reliable testing procedures for water potability. Both inorganic and organic constituents must be considered but the myriad of possible organic compounds that might be present in a water reuse system makes the development of a monitoring system for organic compounds an imposing task.

Three factors must be considered–sensitivity and specificity of detection systems, information derived from a specific detection system, and sampling methods. Moreover, the detection system must be rugged and foolproof in the hands of unskilled personnel.

Bunch. Organic pollutants in water and waste water require increasingly precise description if we are to deal effectively with the complex pollution problems of today. We cannot identify many compounds discharged in effluents from our secondary waste treatment plants. If we are to improve the present waste water treatment processes, the structure or types of these compounds must be determined.

Millions of people in this country depend on surface waters for water supply. With each passing year, an increasing proportion of the raw water supply is reused one or more times. Under these circumstances, it is necessary to identify the constituents of our surface waters and our tap waters to guard the nation's health. Hundreds of new compounds are generated each year and these will require surveillance.

Direct determination of most organic contaminants in water is not possible because they occur in minute concentrations. The usual concentration is less than one mg per liter, and in many cases less than one mg per liter. Some means for concentrating these materials is necessary before analysis and identification can be made. Some of the methods now in use are solvent extraction, ion-exchange resins, activated carbon, distillation, and lyophilization.

Of the wide array of organic analytical methods, few can be applied to aqueous solutions. Many cannot be applied to the analysis of mixtures of organic compounds. Even nominally pure water may contain a large number of organic substances in low concentrations. The most rewarding procedures for identifying contaminants are gas chromatograph, ultraviolet, infrared, and mass spectra procedures.

Cuddeback. The performance of highly sensitive air pollutant analyses requires that samples are obtained in a useable form. Research efforts have been undertaken on various sampling procedures involving the use of solid sorbents as a concentrating device and as a storage device.

Sampling and analysis of NO_2 in air has been accomplished with a copper

metal adsorber coupled with a Coulson conductivity detector. The method has also been used with a microcoulometric detector as the analytical procedure. The demonstrated ability of the solid sorbent for analysis of NO_2 promoted the expansion of the program to other analytical technics and to other pollutants. In the case of NO_2, procedures are being devised to enable a 24-hour air sample to be analyzed by an ion specific electrode or by a UV spectrophotometer. These developments should enable a small basically equipped laboratory to perform trace NO_2 analysis at minimum added cost. A copper metal absorber is under study as a sorbent for other pollutants under examination in anticipation that a multi-function method may be developed.

Williams. Automated analysis may be defined as a procedure whereby some type of system samples, analyses, and reports results without the help of human attendants. These automated systems play an important role in an analytical laboratory supporting pollution control research. This is particularly true at NERC, Cincinnati where a number of pollution control research activities are carried out. These activities involve air pollution, water pollution, and solid waste activities.

A mechanized system that can simultaneously determine several different components in a single small aliquot and provide a permanent record is a valuable asset to the control laboratory. It not only frees personnel for other duties, but provides dependable, accurate analyses in greater numbers than possible through manual methods. Inasmuch as chemists, technicians, aids, and other professional people, and research funds are always limited, automation of analyses is the only way the support laboratory can provide rapid, accurate analyses in the increasingly large numbers that are being requested. In addition to making the performance of large numbers of analyses possible, automation and instrumentation can reduce the cost per analysis to approximately one-tenth of a manual analysis, while providing analytical services not available by conventional procedures.

Austern. Waste water is a complex system containing, among other things, human wastes, water from washing operation, food wastes, industrial chemicals, and a great gamut of organisms which can modify them. A broad spectrum of organic components is excreted in urine and feces ranging from several grams per capita per day for more common compounds such as urea, creatinine, and sterols, to a few micrograms for compounds such as vitamin and hormone metabolites. Some of these compounds have already been identified in sewage and receiving waters and may be used as indicators of recent pollution. Many others may be found in the future unless, like urea, they are quickly degraded by sewage microorganisms.

Many compounds in waste water, especially those from industrial sources, are not biodegradable and conventional sewage treatment, therefore, will not remove them. Of these, many are detrimental to water quality for a variety of reasons. Among these reasons are toxicity to fish or to humans, undesirable taste or odor in drinking water, toxicity to the bacteria that are required in biological sewage treatment, and impairment of quality for industrial purposes. It is imperative, therefore, that methods are found for the analysis of very low levels of these compounds in the presence of other substances which may interfere with analytical technics. With the analytical methods found, ways will have to be determined to remove detrimental materials.

One method of characterizing complex mixtures of organics is by measurement of molecular weight distributions. Besides being a separation technic preliminary to further analysis, such measurements can give useful information for treatment. For example, large molecules may be best removed by coagulation, whereas carbon adsorption may remove small molecules. Comparison of molecular weight distributions of effluents from various treatment procedures may give insight into their mechanisms and assist in optimization.

Kawahara. The discharge of oils into surface waters is one of the more serious water pollution problems.

To establish responsibility for violations of water quality standards and to secure abatement of oil pollution, technical and analytical information is necessary to facilitate locating and identifying the source of pollution created by discharged petroleum products. In the case of spilled crude oils and light fuel oils, changes brought about by weathering present a difficult problem in the identification of affected crudes.

Heavy motor oils, heavy residual fuel oils, and asphalts, because of their high molecular weights and complexity, cannot be readily identified with a source. They are not usually amenable to analysis by the flame ionization detection GC. One feasible approach to their identification is the analysis of the passively-labeled fluorinated phenolic ether and thio-ether derivatives of weak acids contained in heavy petroleum products. These analyses are done by electron capture detector gas chromatography. Another useful technic for characterization of these heavier residual fuel oils and asphalts is infrared spectrophotometry and infrared ratios. To further improve the characterization and to eliminate the small indeterminant region previously obtained, statistical computor analysis is under study.

Ultimate microanalysis, fluorescence emission, and other instrumental technics are under study and consideration.

DISPOSAL OF WASTES

Session Chairman and Editor

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Advanced Waste Treatment Systems for Domestic Wastes

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Tannery and Other Industrial Wastes

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Disposal of Radioactive Wastes

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Radioactive Waste Treatment and Costs

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Dewatering of Sludges

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Management Aspects of Waste Disposal

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Disposal of Hazardous Solid Wastes

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Municipal Incinerator Guidelines

WILLIAM C. ACHINGER, Process Technology Branch, Office of Solid Waste Management Programs, EPA

Combustion and Pyrolysis of Solid Wastes

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Combustion and Pyrolysis of Solid Wastes, and Other Environmental Interests of the Department of Aerospace Engineering

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DISPOSAL OF WASTES

Technology for treating municipal, industrial, and radioactive liquid and solid wastes is developing rapidly. Economic incentives, legislation, administrative guidelines, the philosophy of resource management for recycle and reuse, and engineering science, are mechanisms for achieving pollution control. The need to consider combined municipal waste water, solid waste disposal, and the effect of the operating conditions at control facilities on air emissions and pollutant transport is apparent.

Smith. There are over 500 advanced waste treatment installations in operation or under design in the United States. These systems can be classified as biological, chemical-physical, or combined biological physical-chemical. All incorporate unit processes which are capable of removing nitrogen, phosphorus, and carbon. Phosphorus removal is accomplished by precipitation with alum, iron, or lime followed by sedimentation and filtration. Nitrogen removal is achieved by biological nitrification-denitrification or by physical-chemical methods such as ion exchange, ammonia stripping, or breakpoint chlorination.

Refractory organic carbon can be removed by activated carbon and ozonation. Dissolved inorganics can be removed by electrodialysis, ion exchange or reverse osmosis. Disinfection and virus removal can be accomplished by chlorination, iodination or ozonation.

Waste water can be renovated for a multitude of purposes including agricultural, recreational and industrial reuse.

Eye. The conversion of batch tanning operations to continuous chrome tanning processing has been accompanied by recovery of chemicals and useable protein, and by reduced waste discharges. This illustrates a needed change in philosophy from one of waste treatment to one of resource management.

Brinck. Radioactive wastes differ from other pollutants in that there is no natural assimilative capacity in the environment for radioactivity other than the process of radioactive decay. For this reason, if the quantity of a radionuclide entering the environment, over a given time period, is greater than that lost through decay, there is a buildup of that radionuclide. Irreversible environmental effects may occur if the radionuclide is longlived, such as ^{85}Kr, ^{129}I, tritium, or plutonium.

The EPA is considering the handling and disposal of radioactive wastes within this concept of long-term environmental risk commitment in the development of generally applicable environmental standards. To do this, it is necessary that we develop the best scientific knowledge about the migration of long-lived radionuclides through the environment and the pathways by which they bring about human exposure.

Leonard. After identifying the pathways for release of radionuclides as gas and liquid effluents, performance data on various methods for effluent treatment need to be collected and evaluated. The incremental effects on electric energy costs, which would result from using various systems to reduce radionuclide release, can then be estimated.

The prevailing technology is one of volume reduction, reprocessing, or storage to allow the radionuclides to decay in a controlled and isolated environment such as in burial facilties.

Farrell. Volume reduction is a significant factor in providing cost-effective technology for disposing of waste water treatment plant sludges.

The waste water sludges which must be dewatered are generated by primary settling, biological treatment, and chemical treatment. Combinations of these sludges are generally encountered. Except in rare cases, they cannot be dewatered without some form of conditioning.

Sludge is thickened prior to dewatering by gravity settling, flotation, or centrifugation. Dewatering is carried out by vacuum filtration, centrifugation, or drainage on sand beds. Inadequacies of these methods have led EPA to investigate alternative means such as electroosmosis, capillary suction filtration, top-feed filtration, and magnetic separation.

Conditioning of sludges prior to dewatering is accomplished by addition of inorganic chemicals, polyelectrolytes, fly ash, and by heat treatment. Mass of sludge is reduced by anaerobic digestion. Heat treatment solubilizes a portion of the sludge which imposes an additional load on waste water treatment. Digestion solubilizes some sludge and removal of these solubles may be required before further dewatering is possible. The impact of recycle streams from these processes on waste water treatment costs and means to reduce this impact is being studied.

More rigid requirements for upgrading treatment, particularly for phosphate removal, require addition of chemicals such as lime or alumnium salts, which produces sludges with dewatering characteristics different from conventional sludges. Information must be collected on these new sludges so that accurate estimates can be made of the cost of improved waste water treatment. These waste residues must ultimately be disposed of to the air, water, or land.

Clark. The ever-increasing societal costs of programs for handling our unwanted residues or wastes heightens the importance of efforts to promote their efficient management. Several areas that show potential for improved management are: performance-auditing of pollution control facilities; examination of the effects of public subsidies; choice of air, water or land routes for disposal; and consolidation of municipal waste handling operations.

The construction of physical facilities for waste treatment has proceeded at a pace that has outstripped the development of systems for insuring that the facilities do the job for which they are intended. Routine auditing of performance should encompass overall treatment efficiency, system design factors, and financial management.

Public subsidies for both municipal and industrial pollution control have been directed almost exclusively toward physical facility installations. This emphasis may have resulted in lack of incentive to utilize other technics to minimize the production of wastes. In the water pollution area most major changes in the federal laws in recent years have included an increase in the federal share of the cost of abatement facilities. This trend towards higher federal cost-sharing may retard progress in environmental improvement.

Convenience for waste producer has often seemed to be the motivating factor in deciding whether to release residue to the water, air, or land. Other decision-making criteria may be more efficient in minimizing undersirable environmental impact.

Municipal systems for handling water-carried and solid wastes are often separate operations; yet, they frequently utilize some of the same processes such as land disposal and incinerators. Many waste producers also have the choice of either system for certain waste ingredients. The potential merit in consolidating these systems physically and/or under the same management deserves attention.

Johnson. The disposal of hazardous wastes is a special problem area in managing the 4.3 billion tons per year of solid waste generated in the United States. Hazardous wastes require special attention because of their potential for creating effects of catastrophic proportions if not disposed of properly. Hazardous waste materials can be defined as those materials or combinations of materials which require special management technics because of their acute and/or chronic effects on the health or welfare of the public or upon those individuals who handle them when they are disposed of by waste management practices (i.e. storage, transport, incineration, sanitary landfilling, composting, dumping, industrial waste treatment).

Because many of these materials are difficult or impossible to treat adequately, the time may be at hand when another management technic, legislation, will have to be invoked. Legislation may require substitution of materials if an acceptable method for disposal is unavailable.

Achinger. The promulgation of federal guidelines is a management mechanism useful for transfering technology and insuring minimum standards of design and performance.

The Solid Waste Disposal Act, as amended, requires that guidelines be issued for conventional solid waste management technics, such as incineration. These guidelines are to be implemented by federal agencies and are recommended to states and other regulatory agencies. Guidelines have been developed for sanitary landfill practices and municipal-scale incinerators (defined as incinerators processing more than 50 tons of solid waste per day). The incinerator guidelines address air and water quality, aesthetics, vectors, residue, safety, and hazardous wastes handling as well as site selection, design, operations, and inspections. In every case, a requirement is established, and recommended practices are developed.

Thurnau. While guidelines are useful for the more standard technology applications, there is a continuing need for research on special effects in special applications. Corrosion effects of PVC, metal transport in incinerator scrubbing gases, and pyrolysis of hazardous wastes using molten salts reflect but a few of the current needs.

Kauffman. The attainment of a better understanding of the mechanism of formation and methods for control of combustion-generated air pollutants is an important area of research.

The specific problem of the combustion of solid waste is under consideration in conjunction with the examination of the flame zone structure of a pulverized coal flame. Although reaction zone kinetics are being unravelled for premixed flames and some liquid fuel diffusion flames, the kinetics of the pulverized coal flame remains unknown. Preliminary considerations would tend to indicate that the addition of urban trash to such a flame—as is presently occurring in St. Louis—would tend to lessen the formation of oxides of

nitrogen if significant fuel-bound nitrogen is not present. The effect of the trash combustion on other emissions remains unknown, but any particulate increase would probably prove amenable to treatment by precipitators. The addition of trash may also prove beneficial in that it may increase the heat transfer to the boiler.

Other areas of current interest in the combustion field involve a study of the flame zone in a gas turbine combustor and an examination of the kinetics of hydrocarbon reactions. In the first area mentioned, flame zone parameters such as velocities, turbulence levels, temperatures, and chemical species are to be measured by non-invasive optical technics. With regard to the kinetics problem, a chemical shock tube will be employed to quench combustion reactions so that a species analysis can be made at any time in the combustion process.

The generation of noise caused by the flow of compressible fluids and the control of vehicular traffic are also environmental problems. An anechoic chamber measures noise produced by control valves as a function of flow conditions. The data collected has led to the development of a model, based upon several experimentally determined coefficients, to predict emitted valve noise. The equipment used in this facility includes microphones, sound level meters, a Fourier analyzer, and a real–time spectrum analyzer. Methods of optimal control theory are being examined for their application to the control of metropolitan traffic. The goal of this research is to determine the switching times of signalized intersections of large networks in order to minimize the total delay time for all network users.

EARTH SCIENCES

Session Chairman and Editor

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Sanitary Landfill Guidelines

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Sanitary Landfills

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Travel of Pollutants Through Soil

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Assimilation of Organic Waste by Soil

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Pollution by Surface and Underground Mines

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Biological Contribution to Mine Drainage Pollution

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Surficial Soil Creep

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Hydrology of a River Basin

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EARTH SCIENCES

Pollutants enter the water and earth in several different ways. An understanding of the environment's effects on pollution may be a powerful guide towards abatement.

DeGeare. The first definitive federal control of solid waste resulted when the Solid Waste Disposal Act of 1965 was amended in 1970 by the Resource Recovery Act. In this amendment Congress charged the Administrator of the Environmental Protection Agency " . . . in cooperation with appropriate state, federal, interstate, regional and local agencies, and allowing for public comment by other interested parties . . . " to recommend to appropriate agencies and to publish in the Federal Register guidelines for solid waste management systems. It was further required that these guidelines be consistent with public health and welfare, air and water quality standards, and adaptable to appropriate land use plans. The Sanitary Landfill Guidelines represent, in their present form, the final judgments on the part of the Environmental Protection Agency regarding what is required and necessary to assure both environmental protection and acceptable design and operation of sanitary landfills. They represent objectives that are achievable using today's technology, while providing flexibility for unique and specific climatological, geological, geographical, and related conditions.

Schomaker. The U.S. Environmental Protection Agency's field activity, located at Walton, Kentucky, has as major goals the development of a comprehensive understanding of solid disposal in sanitary landfills, and an assessment of the environmental impact of landfills. The problem areas presently under investigation relate to leachates, gas, settlement, hazardous waste, and health-related effects. Under study at present are analytical technics for pollutant identification; the physical, chemical, and biological treatment of leaches; soil attenuation of leachates; evaluation of liner effectiveness for leachate containment; gas generation, movement, and control; virus and other pathogen survival, movement, and control; settlement prediction and control; and evaluation of the effects of selected unusual hazardous materials (for example, sludges, liquids, pesticides) disposed into sanitary landfills.

Laushey, Preul. Infiltration of waste waters from contaminated streams can pollute ground waters needed for much of our water supply. Research in the Department of Civil and Environmental Engineering is intended to determine geographical extent, strength, and duration of aquifer degradation caused by seepage of polluted surface waters. Results include: 1. the theory and numerical technics for both Darcy's Law for unsteady ground water flow, and the diffusion equation for the degradation of pollutants with time and distance from a source of contamination, 2. a mathematical model for the Great Miami River basin, and analog and digital solutions to predict ground water flow rates and water table elevations during pumping and/or recharge, 3. laboratory tests on chemicals of a reacting type that do not move exactly as the water carrier, but can decay and be adsorbed on particles through a physical process

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(Dispersion coefficients were obtained for hexavalent chromium, calcium, and sodium), and 4. predictions of eventual deterioration of water quality in the Big Bend region of the Great Miami River because studies showed that the major source of recharge of aquifers was the river during normal hydrologic conditions, and significant pumping of the well fields for water supply therefore results in aquifer contamination with constituents of the river.

Long term deterioration of the aquifers can be expected unless the river quality is improved.

Dotson. Spreading organic wastes on soil for disposal decomposition and soil enrichment is an old practice. Soils vary in physical, chemical, and biological properties, but most of them can be used as waste assimilators. Comprehensive evaluations of soils, geology, and hydrology at the sites are necessary to properly design land disposal systems. Deep, permeable, well-aerated, medium-textured, level soils are most suitable for such use.

Many kinds of organic wastes are applied to soils. Stabilized liquid sewage sludge is a good fertilizer and soil conditioner. Sludge may also spread as dewatered sludge cake or compost. One of the most popular, simple, and economical methods of disposing organic wastes is by spreading thin layers of liquid digested sludge on cropland. Prudent sludge spreading on suitable soils has not caused odor or fly problems. Sludges containing high concentrations of heavy metals or other toxic substances should not be spread on land. Some metals are toxic to plants at relatively low levels, so managing to prevent harmful accumulations of soluble metals is necessary.

Overloading soils with organic waste can create many problems. Permissible loading rates depend upon the type of soil, geology, climate, waste characteristics, and land use. Nitrogen is the component in sludge that most frequently limits annual application rates. Digested sludge has been successfully applied to cropland at rates from less than 10 to 100 tons of solids per acre per year. Pathogens usually survive digestion and other conventional stabilization processes. Where there is danger of spreading disease to the public by contact with sludge-treated soils, disinfection should be practiced. Pasteurization by heating liquid sludge to 70 C for 30 minutes has been effective against pathogenic bacteria, viruses, and parasites. Liming to pH 11.5 has also been effective against bacterial pathogens.

Hill. In the United States, over 10,000 miles of streams have been degraded by mine drainage. Acid drainage is a result of the oxidation of pyrite. The resulting low pH of the water produces solubilization of other ions such as Ca, Mg, Cu, Zn, Al, Mn, Na, and As, which are also pollutants. Sediment is also a major problem. Acid mine drainage from active mining operations can be treated by neutralization to remove the acidity and metals. Reverse osmosis and ion exchange can be used to demineralize water.

Technology for preventing acid mine drainage from abandoned underground mines is inadequate. Imaginative new approaches are needed to resolve this problem. The control of sediment from surface mines requires further understanding and development of control technology.

Vestal. Ground waters or surface waters which enter coal mines are weakly buffered in the range of pH 5.5 to 7.5. The effluent waters from coal mines are highly acidic (pH < 3.0 to 3.5). The decrease in pH is caused by oxidation of pyritic materials (FeS_2) associated with coal, and the oxidation of the sulfur

found in low grade coal. The oxidation of the reduced iron sulfide generates ferric precipitates (predominately ferric hydroxide) which give the drainage a reddish to red-brown color. The sulfuric acid produced from sulfur and ferrous sulfide oxidation causes the decreased pH.

These oxidations can occur abiotically, but as the pH decreases, the rate of abiotic oxidations also decreases. Recently, an acid tolerant, iron-oxidizing filamentous bacterium assigned to the genus *Metallogenium* was isolated which oxidizes reduced iron in the mesoacidic pH range (pH 3.5 to 4.5) where abiotic rates are very slow. The microorganism generates acid about 200 times faster than the abiotic rate. This decreases the pH to the acidic range (pH 3.5) where the iron oxidizing autotrophic bacterium *Thiobacillus ferrooxidans* can grow and further generate ferric precipitates and acid. This microbe oxidizes ferrous iron about one million times faster than the abiotic rate below pH 3.5. The organism is obligately acidophilic and does not grow well above pH 3.5.

It may be possible to alter the ecological succession of these microbes in drainage by inhibiting the growth of the mesoacidic filamentous microorganism so that the autotrophic bacterium, which produces most of the acid and iron precipitates, will not grow.

Fleming. Soil creep is a natural process whereby soil materials move slowly downslope. Two general types of creep, continuous and seasonal, have been defined. Continuous creep is deep-seated movement and is the response of soil materials to a change of loading conditions such as might be imposed by a deep excavation, a large fill, or perhaps a glacier. Seasonal creep occurs at or near the ground surface and is the response of soil materials to seasonal changes in such factors as temperature and moisture.

The seasonal creep of a soil in the San Francisco, California, area was studied as part of a continuing investigation of the process. Creep was measured over a two-year period in two field areas on the San Francisco Peninsula. The objective of the study was to develop a stress-strain-time function that can predict the creep behavior of the soil for a variety of loading conditions. Soil moisture and climatic conditions were monitored in the field areas during the same period that creep movements were measured.

The rate of creep measured indicates that, for this soil, creep is responsible for a larger amount of soil transport than erosion. Permanent downslope creep was closely associated with wetting and drying of the soil. During drying, creep movements appeared to be small and randomly directed depending on the location of the point of measurement with respect to surface features such as shrinkage cracks in the soil. Permanent downhill creep occurred on wetting of the soil. During the early part of the wetting cycle, creep movements were rapid, but the rate diminished to a negligible value on continued wetting of the soil.

On a slope inclined at about eight degrees from the horizontal, the net creep of a point on the surface of a five-foot thick layer of soil was about one-half inch per year. Movement was detected through the entire soil profile, but not in bedrock. The profile of deformation typically had a convex upward shape, indicating that the rate of creep continuously increased toward the ground surface.

A tenative model for season creep is proposed in which the logarithmic strain rate is proportional to the ratio of shear to effective normal stress raised to a power.

Shelton. Environmental endowments of moisture and energy are represented by precipitation and evapotranspiration, respectively. Except in the arid areas of the world, more water falls as precipitation than is lost by evapotranspiration from the land surface. Runoff is the residual of the moisture endowment which exceeds the consumptive demands of energy and the storage capacity of capillary water.

Rivers are conduits for the overland transfer of surplus moisture, and the river regime is a product of the integrated hydrologic determinants operative within a drainage basin. The uncommonly uniform flow of the Deschutes River, Oregon, contrasts so markedly with the climatic regime of its basin that it is recognized internationally as a hydrologic puzzle. An understanding of the natural hydrologic processes responsible for the river regime was sought by employing two interlocking models of climatic effect and ground water transmission. The climatic input was accounted as a budget of precipitation supply, evapotranspiration demand, and soil moisture storage in order to estimate surface runoff and ground water percolation. Ground water transmission was treated as a series-storage model to account for the apparent multiplicity of storage mechanisms in the basin.

Elucidation of the behavior of the Deschutes River hydrologic system provided greater understanding of how water is processed at the earth-atmosphere interface. The concept of an interlocking climatic model and a ground water transmission model has potential utility for study of the hydrologic processes of glaciers, recent sedimentary deposits with differing storage characteristics, and diffusion-transmission oddities such as karst topography and volcanic terrain.

ECONOMICS

Session Chairman and Editor

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Management of Water Treatment Systems

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Economics of Waste Water Reuse

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Economics of Resource Recovery in Solid Wastes

RONALD J. TALLEY, Quantitative Research Project, Solid Waste Research Laboratory, NERC, EPA

Wage Incentives for Solid Waste Collection

RICHARD L. SHELL, Department of Management, College of Business Administration, UC.

Process Optimization of Waste Water Treatment

ROBERT SMITH, Treatment Optimization, Advanced Waste Treatment Research Laboratory, NERC, EPA

Cost Sharing and Environmental Impact Statements

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ECONOMICS

The economics of waste water treatment and reuse, and/or solid waste disposal and recycling are critical in pollution control. Both technical and administrative problems lay in the path of final solutions.

Cleary. Concepts of how our nation should manage the quality of its water resources underwent a radical change with the passage of the Federal Water Pollution Control Act Amendments of 1972. When Congress overrode President Nixon's veto of the bill, it enacted what has been characterized as the most arbitrary, costly, and complex environmental law yet.

Congressional aspirations find expression in the declaration that it is the national goal to completely eliminate discharge of pollutants by 1985 – this is the so-called "zero-discharge concept." To implement the law, Congress authorized a $24.5 billion expenditure over the next three years which is equivalent to the entire cost of the space program during the past decade.

Brunner. Waste water reuse applications include agricultural, recreational, industrial, and potable and non-potable domestic. There are examples of all but direct potable reuse in the United States at this time.

The reason for practicing reuse may be an extreme shortage of other water sources. In such cases, the cost of renovating waste water is likely to be very much lower than the cost of alternate sources. The more usual situation is one in which alternate water supplies are still available, but where their cost approaches that for waste water renovation.

The cost assigned to renovation of waste water should not necessarily be the total treatment cost. Some consideration should be given to the fact that treatment for reuse eliminates the treatment cost that would have to be incurred to meet pollution control requirements. The cost of waste water renovation varies widely depending on the application. For irrigation, usually all that is required is conventional secondary treatment and disinfection. The treatment cost for a 10 mgd plant should be 10 to 15 cents per 1,000 gallons. The same system would produce water suitable for some industrial uses. For more general industrial reuse and for recreational reuse, more sophisticated treatment is required. The treatment cost for a 10 mgd plant should be 25 to 30 cents per 1,000 gallons. Potable reuse requires the most complex system, probably including a demineralization step. The treatment cost for a 10 mgd plant should be about 50 cents per 1,000 gallons.

Talley. The extent to which resources are recovered from solid waste is determined by economics. The level of resource recovery is as low as it is because it is not now profitable to engage in this activity beyond a very minimal level. That level is determined by those well-known basic economic forces, supply and demand; the level will change as a result of changes in the underlying determinants of supply and demand.

Environmental concern suggests that the present level of resource recovery is lower than the socially optimal level. In the research arm of EPA, therefore, our overall objective is to provide the analytical basis for making the proper policy decisions regarding resource recovery. These decisions include determining the

levels of resource recovery to strive for, and the kinds of action to take.

Government actions in resource recovery affect the supply side, the demand side, or both. Until fairly recently, the relative emphasis was on stimulating supply. There has been a growing realization however, that there is no point in reclaiming materials for which there is little or no demand. So, now the emphasis is on stimulating markets. There are many possible forms which Government action could take to accomplish this. One which EPA is presently engaged in is subsidizing the development of new uses for, and new technologies to use, materials in solid waste.

Other possibilities include use of the tax system. For example, the EPA currently has a plan under consideration which would grant a tax credit for the use of materials reclaimed from solid waste. Any Government actions, however, must overcome the substantial obstacles posed by two very well-developed systems that are inherently antithetical to increased resource recovery: a production system designed to run on virgin materials, and a solid residuals handling system oriented toward disposal.

NERC, Cincinnati's efforts in the area of the economics of resource recovery include several studies on the materials in solid waste (combustible materials, and the noncombustible materials, ferrous metals and aluminum), a study of the effects of existing Government programs on resource recovery, an investigation of the effects of transportation costs on materials recovery, a study of the salvage industry, and an analysis of possible incentives for greater paper recycling.

Shell. A large scale research project is being conducted by a group of UC faculty to determine the feasibility of incentive wage systems for solid waste collection personnel.

Over 190 million tons of solid waste will be collected in the United States during 1972. This will require a major expenditure for most municipalities totaling approximately $5 billion nationwide of which over 70 percent will be required for labor. New technology developments in equipment and containers may improve waste collection, but future systems will still be highly labor intensive. The need is clear for increasing collection productivity.

Investigation of the feasibility of team wage incentives for solid waste collection and disposal personnel is the objective of a current EPA-supported research project (R801617).

The overall collection system must be well-structured before a wage incentive program can be developed. A precise definition of collection method must be determined, and the capability to accurately compute work content must be available.

Wage incentive development must consider citizen requirements, and municipal management, worker, and union interests and attitudes. Common goals must be established for all groups.

Predetermined time systems such as MTM, stopwatch timing, and work sampling are the work measurement technics best suited to analyze collection activities that typically have wide variation in cycle times and frequency of occurence. Major area of investigation include establishing individual and team earnings, worker turn-over and morale, quality of service, and comparison with established wage incentive programs in manufacturing and other service industries.

Collection costs for labor, capital, and overhead must be evaluated and the

total economic impact must be weighed to determine overall benefit. An operating wage incentive program with increased productivity should benefit citizens, municipal management, workers, and the union. Citizens should be afforded either lower taxes and/or improvement in other municipal services. Operating management problems should be eliminated or significantly reduced. Workers should enjoy higher earnings, and the union should be able to participate in goal setting and realization.

Smith. The Treatment Optimization Research Program at NERC, Cincinnati is concerned with finding realistic relationships between the cost of collection and treatment of waste water and the effectiveness of the treatment system used. Digital computer models are used extensively to make the necessary computations and copies of these programs are widely used by universities, engineering design firms, and governmental planning groups. We are concerned with the assessment of national impact of waste water treatment in terms of cost and utilization of resources such as chemicals or electrical power, and with the economic feasibility of concepts such as advanced waste treatment for nutrient control or for reuse and consolidation of plants by means of pipelines. Conventional treatment alternatives are studied extensively. From such studies, we try to determine solutions to problems such as whether flow equalization should be provided, whether primary settlers should be used, which modification of the activated sludge process should be used (for example, completely mixed versus plug flow), which aeration system is most economical, which sludge handling schemes are most advantageous, what is the most economical method for post aeration, and what levels of instrumentation should be used. A major part of our current work is centered on the sludge handling system. Most of these questions are not new, and our work does not determine the best solutions for all situations.

The recent Federal Water Pollution Control Act of 1972 indicates that there is a growing awareness of costs and an interest in setting effluent standards for both industries and municipalities. However, the effluent standards are to be related to the state of the technology and to reasonable costs for treatment. The term "best practicable treatment" is used throughout the water bill, and this term is defined to cover such factors as total cost in relation to the effluent reduction benefits to be achieved, the age of equipment and facilities, the processes employed, the engineering aspects of applying various control technics, process changes, and non-water quality impact including energy requirements.

Lee. The National Economic Policy Act (NEPA) opened the door to a new era in how decisions are made about what man will build and where. Already the system is working; already planning is much more costly and time consuming. The interested public can join in governmental decisions, for planning is now done in a fish bowl. Ten states and Puerto Rico have copied the Federal Act, and actions are pending in many others.

The teeth in NEPA lies in Section 102, requiring filing an environmental impact statement (EIS) for each activity having 'a significant impact on man's environment' involving any Federal dollars, grant-in-aid, or regulatory and licensing actions.

After about 200 court tests, there is no question that NEPA requires full disclosure. All of the arguments, pro and con, come into the open. All of the

benefits and costs, tangible and intangible, are spelled out.

Although both NEPA and the implementing guidelines from the Council on Environmental Quality require estimation of the second order effects induced by a proposed project, the agencies are not doing this – largely because they do not know how. The University of Cincinnati has submitted a research proposal to prepare instructions on how to do this for typical public works projects.

There soon may be a court test on this point, perhaps leading to a decision that secondary effects must be estimated in every EIS. Should this happen, the possible effects stagger the imagination. For example, all of the beneficiaries of a project would be identified, including those who may reap a windfall from increased land values and uses. Very quickly, in view of the attitudes of the present administration and many members of congress, I would anticipate a demand for discarding the present grant-in-aid cost sharing formulae. To follow would be the allocation and apportionment of cost of highways, sewage treatment plants, and many other federally supported works in much the same manner as is now being proposed for water resources investments.

EDUCATION

Session Chairman and Editor
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Training Programs in Environmental Health Sciences

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Training Program of the National Training Center

JOSEPH F. SANTNER, National Training Center, Office of Air and Water Programs, EPA

Training Program in Environmental Engineering

JAMES M. MORAND, Department of Civil and Environmental Engineering, College of Engineering, UC

Training Program in Solid Waste Management

THOMAS J. SORG, Planning and Training Branch, Office of Solid Waste Management Programs, EPA

Prospects for Environmental Study Programs at UC

THELMA WURZELBACHER, Department of Biological Sciences, College of Arts and Sciences, UC

Undergraduate Environmental Control Technology Programs

JUDITH M. SCHULTZ, Department of Biology, Raymond Walters General and Technical College, UC

Training Program in Water Supply

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EDUCATION

A broad spectrum of environmental educational opportunities are available in Cincinnati. These range through two-year associate programs, four-year bachelor's programs, and the master and doctoral degree program. In disciplines, they include chemistry, biology, engineering, and medicine. Opportunities extend to training and continuing education for updating and upgrading individuals already in the practice of environmental protection.

There is evidence that many new opportunities are opening up for EPA personnel to participate in the educational and research program of the University, and for UC students and faculty members to participate in the training and research programs of NERC, EPA.

At some point, some plan of reciprocal course registrations between EPA and UC may be beneficial to increased interaction.

Suskind. The Department of Environmental Health provides graduate instruction for masters and doctoral students in the fields of environmental medicine, toxicology, industrial and environmental hygiene technology, radiologic health, biostatistics, epidemiology, and a general program in environmental health sciences. It offers instruction in environmental and community health problems for medical students, and research experiences for post-doctoral fellows in the environmental sciences. Non-degree instruction is also provided for persons who seek highly specialized training in specific areas of environmental science. The training program of the department essentially emanates from its research efforts which are devoted to the study and examination of environmental hazards affecting human health and welfare. The broad scope of interests and diverse staff capabilities, whose efforts range from the study of fundamental mechanisms of adverse biologic reactions to mission-oriented studies and surveillance work, provide an effective facility for research training. Currently, the present staff capabilities represent over 20 biomedical and physical science disciplines.

During the past several years, there has been a substantial increase in national and regional manpower requirements for persons with professional and scientific qualifications in the environmental health sciences. Career opportunities are among the best in the physical and biologic science area. This has led to a three-fold increase in the number of graduate students within the last three years, and an increase in the quality of the applicants. Currently, there are 70 graduate students, 51 of which are full-time. There are 13 post-doctoral fellows. Many students from other colleges of the University are registered for course work in the department.

Santner. The objectives of the National Training Center are to provide direct technical training in the causes, prevention, and control of water pollution. The training offered is not readily available elsewhere. It includes both the current philosophies and practices in water quality management and recent developments in the fields of sanitary engineering, chemistry, aquatic biology, statistics, and microbiology. Courses involve classroom, field, and laboratory sites, with course content updated at least annually, and often

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specially designed for particular types of student bodies.

Over 70 different courses are available that vary in length from two-day introductory type seminars to two-week intensive lecture-laboratory type formats. Instruction is provided by a core of National Training Center professional staff, supplemented on special subjects by technical specialists from various EPA programs. Additional instructional technics utilized include television, audio-visual instructional units, and home study courses.

An estimated 40,000 students have attended these courses in the last 20 years. They have been offered in nearly every state in the union. About 75 percent of the students are equally divided between state and local government, EPA, and other federal government agencies. Approximately 20 percent are from the private sector and the remaining 5 percent are foreign students. Their educational background ranges from high school training through the doctorate degrees.

Morand. The graduate program in environmental engineering within the Department of Civil Engineering at UC was started in 1958. Initially, the program was operated along the lines of traditional sanitary engineering, with major emphasis on the engineering aspects of water supply and water pollution control. In 1966 the program was expanded to include training and research in air quality management.

The program has been broadened to include staff members with non-engineering degrees, and to admit students with non-engineering first degrees. The graduate-program was arranged so that students could participate on a full-time or part-time basis or on a co-operative plan. The graduate program was further expanded and broadened by offering most of the required courses in both the day and evening programs.

New offices and laboratories comprising approximately 13,000 square feet of floor space were made available to the environmental engineering group in September 1970. In addition to the regular laboratories, a field site is available a few miles from the University for field-oriented research and training activities.

Since the program's inception, 158 M S and 11 Ph D degrees have been awarded by the Department of Civil and Environmental Engineering, with an average annual productivity over the last five years of 22 master's and two doctorates. The program has been accredited by ECPD since 1966.

Sorg. The Office of Solid Waste Management Programs (OSWMP), EPA has three programs on solid waste management training: direct training course program conducted by The Training Academy of OSWMP, university training grants, and state agency training grants. The Training Academy conducts one to three day courses on solid waste management in Cincinnati, and at other field locations, for sanitary engineers and sanitarians, supervisors of public and private collection and disposal systems, and for planners, elected officials, and personnel from federal or state installations. The courses presently available are *Elements of Solid Waste Management, Solid Waste Collection,* and *Principles of Sanitary Landfills.*

In addition to the direct training program, training grants are available for universities and State agencies. University grants provide financial assistance to universities to support the development of graduate programs in solid waste management, and for graduate students in these programs (tuition, fees, living

stipends). Eight universities have grants for the 1972-73 school year; The Universities of Wisconsin, Oklahoma, Iowa, Washington, Southern California, Hawaii, West Virginia, and Georgia Institute of Technology.

State solid waste grants provide financial assistance to state agencies for developing state solid waste training programs. The states that have grants (12) conduct short courses and seminars on all aspects of solid waste management.

Wurzelbacher. Fifteen University of Cincinnati faculty members from six colleges and eleven departments have been actively concerned with a full year interdisciplinary, undergraduate course entitled *Man and Environment.* Fostering environmental awareness and promoting literacy on environmental issues has been a prime objective of the course.

To what extent and in what manner should UC faculty and related agencies pursue undergraduate environmental education?

The dimensions of this question include assessment of student need, accommodation to the present university situation, and collaboration among UC faculty, EPA personnel and community resources. If an environmental studies curriculum were inaugurated, the nature of the administration required as well as the general obstacles and challenges involved in interdisciplinary work would need serious consideration.

Possibilities for an environmental studies program include a continuation of the present offering, additional courses directed toward a minor in an existing degree program, a special Institute for Environmental Studies with joint and cross faculty appointments, or a new Environmental or Interdisciplinary College.

Schultz. A vital and emerging consideration and challenge during the 1970's for institutions of higher learning will be to translate the environmental awareness and enthusiasm of the young generation into meaningful career commitments. Thus translated, an army of career specialists could develop to actually begin to resolve current degradation of the environment.

Although a resource of nearly 50 percent of our youth currently reside in institutions of higher learning, many are more suited to two-year programs than to baccalaureate orientation. In addition, current salary scales and opportunities for two-year graduates exceed those for similarly-trained four-year environmental technicians, demonstrating a problem of over-education which has often occurred in the nation, and making the four-year degree in this field somewhat obsolete.

The Raymond Walters General and Technical College of the University of Cincinnati began in 1972 a two-year Associate in Science degree program in Environmental Control Technology which represents the first undergraduate program in environmental studies at the University to date. The program emphasizes interdisciplinary and multidisciplinary approaches to environmental problem-solving and utilizes the expertise of engineers, ecologists, behavioral scientists, politicians, planners, designers, and health personnel in lectures, courses, and program consultation.

Strongly based in the sciences of biology, chemistry, engineering, and physics, the program also carries a balance in the humanities required by its accrediting source, the National Environmental Health Association, which designated it one of the outstanding programs in the field. The program is comprised of six quarters of study, including one quarter of internship.

Currently, three major divisions of the Environmental Protection Agency (National Environmental Research Center,National Field Investigations Center, Solid Waste Management), the Department of Civil and Environmental Engineering, and the Institute of Environmental Health are intimately involved in the courses of the program, as are five colleges, ten additional departments, and twelve community resources.

Federal, state, and local resources project tremendous increases in needs for environmental technicians both in government and in the private sector which should emerge as opportunities by 1974-75 when the first graduates of the program will seek employment. Two years of research preceded initiation of the program, which is based upon estimates of opportunities, as well as a national curriculum survey of 574 institutions and extensive university and community consultation. Emphasis in the program centers upon air, water, and solid waste control technology and thus the program is broadly-based incorporating an inherent flexibility to adapt to new situations in a rapidly changing world. The graduates, therefore, are specialists with broad-based background, rather than generalists. Program participants are trained as assistants to environmental scientists and health officials.

Jeffrey. The greatest training need at present, is among the more than 70,000 people who manage and operate the water supply systems that provide drinking water to the citizens of this nation. On the other hand, the most serious shortage in manpower is among engineers, technicians, and laboratory staff to conduct adequate surveillance and technical assistance programs. To emphasize the training of operators without first, or at least concurrently, addressing the second problem, would have little impact on improved drinking water quality, since training program post-course success for managers and operators depends heavily on adequate follow up and technical assistance programs. A dual thrust must be made, therefore, to ameliorate both of these deficiencies.

The Water Supply Division is attempting, as resources permit, to present a balanced program attending to the needs of both of these categories. The program has historically been directed to technical people at the college or post-college level. During the past two years, two new courses have been developed that are directed principally to operation and control. These two courses are, *Operation and Control of Community Water Systems,* and *Fluoride Determinations in Water.*

A number of requests have been received for these courses from locations that are rather distant from Cincinnati and from people who are unable to get away from the job for more than one or two days at a time. These courses have been developed, therefore, so that they be presented in the field with the cooperation of state and local water supply agencies. They have met with great success.

Various portions of these programs are now captured on television tape so that they can be used to supplement training courses. They are also used as independent units for individual study. As resources improve, the Water Supply Division plans to develop more support training material with visual and printed media to cover basic principles and applicable research results.

Although student contact may be the most enjoyable part of training, it is quite likely that the greatest input to a national training program would be the development of training materials that can be used in support of a hoped for

proliferation of state and local training activities. It is in this manner that the division can most rapidly and effectively influence the training programs that will be essential if the operation of all water supplies in this country are to approach the level of excellence that modern technology makes possible.

ENFORCEMENT

Session Chairman and Editor

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The Water Pollution Control Act Amendments of 1972 and the Creation of the Regulatory Structure to Govern Industrial Wastes

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Regulation Under the Air Quality Act as Amended in 1970 as an Enforcement Tool

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Enforcement Investigations: Planning, Logistics, Performance

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Enforcement Actions to Attain Compliance

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Change and Consensus in Environmental Politics

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Base vs. Mobile Laboratories in Enforcement

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ENFORCEMENT

Although voluntary compliance with environmental regulatory schemes is the norm, the availability and proper use of enforcement tools in appropriate situations is a necessary element of a viable statutory program of pollution control.

Vanderhoof. In an address entitled "Water Pollution and the Rule of Law," John R. Quarles, Jr., Assistant Administrator for Enforcement and General Counsel, EPA, said that the key to an effective regulatory system is that there be firm, specific requirements imposed on all parties with evenhanded fairness. The exact requirements must be clearly understood and publicized. They must be uniform and strictly enforced.

The chief factors of the new system, according to Quarles are:

First, the law mandates establishment of effluent limitations. These will be specific numerical requirements setting forth precise upper limits on the waste loads which a plant will be permitted to discharge into our waterways.

Second, the law establishes higher standards for pollution control. The law specifies that each industry must, by July 1, 1977, meet effluent limitations reflecting application of best practicable control technology currently available, or in cases where the receiving water requires more stringent control, then higher levels of treatment or control must be achieved. This will establish at the minimum a uniform national standard applicable to all plants wherever located. During the next five years, all plants must undertake abatement programs to achieve the new control requirements.

Third, the new law creates a national permit program. Every industry will be required to obtain a permit under Section 402 of the law. Issuance of these permits will provide the mechanism through which the new more stringent abatement requirements will be set. These permits will contain in a single document the complete schedule of requirements for each individual.

Fourth, the new law establishes tough penalties to enforce compliance. Violations of permit conditions or other requirements will be subject to civil penalties of up to $25,000 per day.

The new national permit program has considerable background. Many states already have permit programs. In addition, EPA has been working for two years to lay the foundation for an effective national program. EPA has about 23,000 applications submitted under the Refuse Act Program established by President Nixon in December 1970. EPA is concentrating efforts on about 2,700 major dischargers, who we believe in the aggregate account for the vast majority of all industrial wastes discharged into our waterways. The determinations of best practicable control technology currently available must be made individually for each plant.

Permits under the new program will specify effluent limitations that must be met after anticipated abatement programs have been completed during the first few years. These will set firm targets for each company's engineers. The permits will set effluent limitations applicable during the interim. Permits will require continuous monitoring by the major dischargers, with frequent reports subject to the penalties of perjury. All of the permits and all of the reported

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data will be made available for public inspection.

The new law authorizes EPA to begin issuance of permits under Section 402. It also contains detailed provisions for approval of State programs to authorize the states to assume operating responsibility for the new national permit program.

The new legislation has also expanded the scope of the permit program beyond its coverage under the Refuse Act. All municipalities will be required to obtain permits. Feedlots and irrigation return flows will also be brought into the system.

These new requirements will usher in a new era of effective regulation. This will benefit society by the achievement of clean water. It will provide substantial benefit to the regulated industry which include clarity, predictability, and assurance that competitors are subjected to comparable requirements.

Kessler. The enforcement planning commitments in many areas have centered so much upon particular methods and/or devices that the entire regulatory scheme has become unstable. The projected regulatory scheme for the Air Quality Act as Amended in 1970 is a perfect example of virtually single focus regulation. The legal ramifications of certain central measures are in doubt, and there is a substantial possibility that basic regulatory devices may be unconstitutional.

The most obvious example is the almost complete dependence upon source self-monitoring. Without self-reporting, there is no method of determining, let alone achieving, compliance with the Air Quality Amendments. Judgements about emission levels and conformity with source compliance schedules rest upon the information reported by the source. That some check of compliance could be achieved by assessing equipment purchases and installations does not remedy the problem. The key to abatement is emission reduction, not equipment.

Another area of instability is indicated. Determination of regulatory success under the Air Amendments requires the achievement of the Ambient Air Criteria. Yet the device used to reach these criteria - and this is in no way to imply that the device is not appropriate, just that it is dangerously exclusive - is the emission standard (in the state implementation plans, and as directed for new sources by the federal government). In pursuance of these emission standards, we are requiring vast expenditures by the sources. What happens if the model was wrong? Emission standards are miraculously achieved, but ambient air still fails the test. The Delaware River Basin Water Control Program indicates this is a possibility.

The state plans do require some expenditure to monitor the ambient air. But the focus is so exclusively on emission standards, it is doubtful that adjustment of these standards can be made until after the expenditures, and the failure, are realities. The result may be chaos. If Section 109 were used to adjust the criteria to reality, the resulting law suits would almost equal the number generated by changing the permitted emission standards [Sect. 110(2)(h)].

The problem is tying sources to long range abatement schemes before the hard data are available. The problem could have been avoided if the emission standard were the actual regulation. It is, however, only a vehicle to that regulation. Thus, the indicated dangers.

Finally, the type of ivory-towerism that leads to such reliance on

self-monitoring and emission standards seems to be affecting the toleration of citizen participation. The Act clearly indicates a Congressional desire to have such participation. But to be effective, the citizen must reach the point at which decisions are being made. Using the decision to extend compliance with photochemical oxidant standards until 1977, as an example, the centralization of decision making, on what is really a variance, endangers any useful public participation prior to taking a court appeal of a decision, already made, which bears the presumption of correctness and regularity.

Sidio. The term *enforcement investigation* requires that information obtained must be legally defensible. Data obtained in the past may be used to establish conditions that "did" exist.

Planning. The purpose and objectives of the study must be defined and recorded. Are the sources of wastes, the receiving waters, or both to be studied? The selection of a person to direct the investigation depends on the nature of the study.

As much background information as possible must be obtained. Sources must include: 1. state pollution control agencies, 2. interstate agencies, 3. water supply treatment plant records, 4. waste treatment plant records, 5. past federal, or other, pollution control reports, and 6. federal agencies.

Observation of the area of concern is mandatory. Field studies cannot be planned or performed from behind a desk. Preliminary field work must include: 1. visit to each source of waste, 2. selection of sampling points - at sources and in receiving waters, 3. determination of distances involved, 4. notes on all observations, and 5. pictures. A preliminary study plan must include: 1. a map of the area, 2. sampling points and frequency, and order (routing) of sampling, 3. flow measurements, 4. special supplies and equipment needed, 5. laboratory determinations required, and 6. personnel requirements. A meeting of all personnel involved for preparation of a final study plan is the last act in planning an action.

Logistics. It is important to assign specific responsibilities (for example, sampling crew chief, lab chief). Preliminary field sampling and analyses are desirable. Length of sampling runs, sampling schedules, and necessary flow measurements can be established in this way. The coordination of moving in personnel, mobile laboratories, vehicles, boats, and sampling and gauging equipment requires good planning.

Performance. Preconceived study plans may be adjusted as needed, but only as needed. When adjustments are made, personnel involved must be advised immediately. Good communications are a necessity. All personnel involved are part of the field team. Each must have a responsibility and maintain a record of activities. On his part of the study, each may be considered an advisor to those in charge.

Gruber. The investigation of a potential or an obvious air pollution source is only a phase of the compliance program. Enforcement is the culmination of the series of events which constitute a complete air pollution control program. Enforcement tests the effectiveness of the regulations to accomplish the air quality objectives of the law.

There are three enforcement systems: 1. surveillance of potential pollutant sources for observable violations, and answering citizen complaints, 2. field inspection following the granting of a permit to construct or prior to the

issuance of a certificate of registration, and 3. conducting a scheduled reinspection of potential air pollution sources on an annual or other appropriate time scheduled basis.

In all action systems, compliance to correct violations is secured through direct order to abate (or comply), administrative hearings to establish a compliance schedule, and legal action through the courts either by assessing fines for provable violations or by injunctive procedures.

Enforcement programs are people-oriented. Manpower development and training are all important to a successful operation. System design and management are the responsibility of professional engineers. Field personnel with engineering skills and training coupled with such personal qualifications as judgement, tact, persuasive communication, and firmness will work for the objectives of the program. Enforcement training in legal procedure and effective presentation of evidence is essential for the successful conduct of the field enforcement effort.

University training at the professional level is essential, but it is also most helpful at the non-professional enforcement officer level.

Heinlein. Environmental politics has had a relatively brief and, recently, spectacular existence. Within the space of a decade, a staid conservation movement became an ecological crusade. The basic assumption herein is that the environmental problem is a political problem. The use the public wants to make of its environment must be maneuvered through the intricate workings of opinion into public policy.

In any society, regardless of the particular political system, attitudes held by the general public form the ultimate parameters of governmental action. Samplings of opinion have shown great change over the past few years, and appear to point to an emerging consensus. First, there can be no doubt that majority opinion is aware of, and anxious that something be done about, environmental pollution. Second, beyond awareness, there seems to be general conviction that government must act.

Within the space of a few years, a nothing issue has become as familiar as taxes and tariffs. Now, everyone is in favor of the environment; it has assumed a place alongside mother and flag. The encouraging fact is that political momentum, stoked in part by the emotionalism of recent years, has built up soon enough and has lasted long enough to produce the institutionalization of the government's responsibility for the health of the environment.

Rosen. Well-prepared pollution enforcement efforts depend on the evidence yielded by scientific investigations employing both mobile and base laboratories. Wherever performed, laboratory evidence-gathering is an optimum combination of four essential characteristics: identity of samples, authority of methods and personnel, timeliness of results, and appropriateness of investigation methods to specific enforcement needs. The options range from simple field analysis kits to complex computer-coupled base laboratory instruments using, for example, mass spectrometry or isotope dating. Every decision on where to make the effort involves a trade-off of the four requirements. Field laboratories reduce the problem of chain-of-custody (identification) of samples and allow the thrust of timely data to guide the scope of the investigation. Base laboratories allow enough sophistication to use legally-defensible methods and to extract the maximum pertinent evidence.

Only a leadership soundly based in both the breadth and depth of science can effectively make these decisions on laboratory utilization.

ENVIRONMENTAL MEDICINE-1

Session Chairman and Editor

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Toxicology of Fuel and Fuel Additives

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Environmental Carcinogens

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Automobile and Diesel Engine Exhaust Facility at NERC, Cincinnati

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Automobile Emission Test Facility at the University of Cincinnati

JOHN N. PATTISON, Department of Civil and Environmental Engineering, College of Engineering, UC

Estimation of Relative Toxicity

YOU-YEN YANG, Experimental Statistics Section, Environmental Toxicology Research Laboratory (Air), NERC, EPA

Assessment of Body Burden of Toxic Metals

PAUL B. HAMMOND and STANLEY B. GROSS, Department of Environmental Health, College of Medicine, UC

Criteria and Standards for Environmental Pollutants

HOWARD E. AYER, Department of Enviromental Health, College of Medicine, UC

Biomedical Impact of Airborne Algae

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Detection of Environmental Mutagens by Bacterial Tester Strains

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ENVIRONMENTAL MEDICINE-1

Detection and quantification of hazardous pollutants are requisites for determining their biomedical impact upon the environment. Determination of this impact is requisite for the construction of intelligent criteria and standards.

Stara. The combustion of fuels used for transportation, heating, and supply of power generally result in emissions, which, in higher concentrations, exert harmful effect on public health and welfare. The mixture of fuel additives with fuels influences the character and toxic potential of the emissions. Moreover, the combustion products of motor vehicle fuels and fuel additives may impair the optimal performance of pollution control devices.

The appropriate evaluation of toxic effects of emission pollutants at the existing and higher levels, particularly in populated areas where mobile and stationary fuel emission sources are concentrated, has national significance. Currently, the 107 million motor vehicles registered in the U. S. consume about 130 billion gallons of fuel per year and emit close to 80 million tons of pollutants into the atmosphere. The yearly usage of fuel additives is estimated at 870 million pounds. Under proposed new regulations requiring registration of gas, diesel fuel, fuel and heating oils, aviation fuels, crank case lubricants, liquified petroleum gas, and additives, an estimated 1,500 compounds are likely to be registered. To determine satisfactory atmospheric standards, it is necessary to assess the associated toxicologic hazard before the new compounds are registered and introduced into the environment.

EPA has a congressional mandate, expressed in the Clean Air Act of 1970, to control or prohibit the manufacture or sale of any fuel or fuel additives when emission products will endanger public health and welfare or will impair the performance of any emission control device. The presently proposed Toxic Substances Act provides further need for extensive biological effect research.

Bingham. Carcinogenic bioassay of environmental contaminants has been carried on at the Kettering Laboratory for several years. The goals of the studies are: 1. investigation of the effects of low-level exposures to certain carcinogens and cocarcinogens so that predictions of the potency of complex mixtures or multiple low-level exposures to various environmental agents may be more accurately made, and 2. active pursual and examination by laboratory tests on animals of the potential hazards associated with certain industrial and environmental exposures, and the chemical estimation of certain known carcinogens in certain environments.

Since polycyclic organic matter enters into the urban environment from a variety of sources, it has been of interest to characterize the contribution of cocarcinogenic fractions to the potency of the whole mixture. Thus, we have developed data on the dose-response relationship of different concentrations of carcinogens (benzo(a)pyrene and benz (a)anthracene) and cocarcinogens.

Our specific aims have been to: 1. establish the concentration range of several long-chain hydrocarbons required to produce a cocarcinogenic effect, 2. determine the role of the concentration of carcinogen on the effective threshold concentration of cocarcinogen, and 3. define the minimum effective

dose of carcinogens that can be detected using a long-chain hydrocarbon as solvent diluent.

Experiments exploring the concentration levels of carcinogens and cocarcinogens necessary to produce tumors demonstrate that there is a 1,000-fold increase in the enhancement of potency of low concentrations of benzo(a)pyrene and benz(a)anthracene when n-dodecane is the diluent. The effect of cocarcinogens is most obvious during exposures to low concentrations of carcinogen. The implications of this observation in environmental situations are extremely important.

Campbell. Mandates of the Clean Air Act as recently amended include the assessment of relative health hazard of various fuels and fuel additives. Existing facilities for generation of automobile exhaust for studies of its toxicity have been modified and augmented to meet the more demanding current needs of testing comparative toxicologic impact of various fuels and fuel additives used in automotive and diesel systems.

The three major components of the fuel emissions toxicologic test facility are: 1. generation and delivery, 2. atmosphere characterization, and 3. bioeffect systems.

The current physical systems include: 1. air purification–chemicals and particulate filtered, and temperature/humidity conditioned, for exhaust dilution and supply of clean (control) air atmospheres, 2. engine/dynamometer–two (alternate) 1972 Chevrolet 8-cylinders 305 CID automobile engines with automatic transmissions, and two Lister 2-cylinder diesel engines, coupled to flywheel-dynamometer units (engines are controlled automatically and operated in a cyclic "driving" pattern), 3. dilution and colling–automatic CO ration control produces constant rate of air: exhaust dilution at multiple levels, 4. irradiation chambers–artificial sunlight acts dynamically on diluted exhaust atmospheres to permit photochemical reactions of pollutants, 5. atmosphere characterization–automatic analysis and recording of primary gaseous pollutants, with computer summaries, and supplemented manual determinations, and 6. animal exposure chambers–28, of 44 C.F. volume, with adjustable ventilation rates and pressures.

Controllable, stable, pre-established generation, performance, and emission profiles are important. Multiple interrelated operational factors have been found to influence these design conditions.

Pattison. The University of Cincinnati has an automotive emission research facility on the 400 level of Rhodes Hall. It includes a chassis dynamometer, constant volume sample; and analytical instruments for determining hydrocarbons by FID, nitric oxide by chemiluminescence, and carbon monoxide and carbon dioxide by NDIR as specified in the current federal test procedures. Catalytic converters have been built into the equipment so that the NO analyzer can determine NO_x and the CO_2 analyzer can determine total carbon content.

Equipment is on hand for field testing, ignition diagnosis, and engine maintenance. A CFR engine is also available for fundamental studies of combustion and emissions.

The research in this laboratory has largely centered around reducing air pollution from vehicles in actual use. This includes development of a diagnostic procedure to pinpoint causes of increased hydrocarbon and carbon monoxide

emissions from controlled and uncontrolled cars due to ordinary use and maintenance, and a technic for determining the actual performance of carburetion systems by precise exhaust analysis on cars in use. This technic will be used to determine the causes of poor carburetion of cars in use.

In other studies, we have determined the amount of airborne particles resulting from tire wear under various driving conditions, and the most probable mechanism of catalytic reduction of oxides of nitrogen in automotive emission control systems.

Yang. Estimation of relative potency is possible only when the parallelism of two probit regression lines is true. However, in many types of investigations, the parallelism may not hold true and estimation of relative potency is of no practical use. An alternative method has been developed for examining relative toxicity at different probit points when such difficulty arises. This method is important because it provides some background information to the investigator for further studies, and because it establishes optimal intensity of the stimulus applied to the subject.

Hammond, Gross. The body burden of environmental contaminants such as toxic metals is a vital index of the impact of the environment on man, and may be critical for the safety of man's health.

Body burden may be measured anatomically and physiologically. Anatomic measurements may include the influence of factors such as variable exposure rates, pathological states, and amounts of blood in tissues (ranging from ischemic to congested conditions). The physiological measurements may involve the use of metal-mobilization with chelating agents as a measure of body burden.

Ayer. Perception of damage from a substance or effect in the environment is followed by official summaries of facts (criteria), and laws or regulations designed to reduce the undesirable aspects of the pollution (standards). Such criteria and/or standards have been produced for surface water, for air, for workplace contaminants and physical conditions, and most recently for community noise. Criteria and standards for land use and solid waste disposal cannot be far behind.

Physical and biological scientists and engineers from the University of Cincinnati have participated in developing criteria for water quality, community air quality and quality of the workplace. This participation has varied from reviews of drafts or draft sections to preparation of entire drafts.

Current work in biological and physical sciences and engineering at the University of Cincinnati will be useful in development of criteria for specific contaminants (for example, trace metals and carcinogens, in air, water and workplace). Development of standards requires participation of other disciplines present at the University of Cincinnati, including economics, business, sociology, psychology, and community planning.

Publication or report of research findings may precede only by months their use in governmental regulations. Interaction of university and governmental scientists can materially aid in production of effective and reasonable standards.

Bernstein, Safferman. Since 1964, the University of Cincinnati Medical Center and the National Environmental Research Center have been

involved in cooperative interaction on the relationship between human respiratory allergy and air-, water-, and soil-borne algae.

In seeking definitive information in this field, it became evident that *Chlorella* was the organism of choice in examining the biomedical impact of algae in human hypersensitivity. Interestingly, members of this genus resemble common pollens in size and shape. Preliminary investigations revealed the specific allergenicity of algal extracts by skin testing, passive transfer antibodies, and direct bronchial provocations in allergic individuals. If atmospheric dissemination of algae was as widespread as indicated by the significant number of immunologic responses to these organisms, a common route of exposure was probable. Thus, the incidence of viable algae in house dust was explored, and we demonstrated that a variety of algae could be consistently cultured from household dust specimens.

To quantitate the exposure dose required in the induction of clinical sensitivity, we developed an intranasal challenge test utilizing intact algal organisms which simulated the natural route of exposure. A good correlation between nasal response, degree of skin sensitization and other *in vitro* correlates of immediate hypersensitivity was observed. These combined diagnostic procedures offer a new approach in defining the importance of algae as a cause and as a possible therapeutic modality in human respiratory allergies.

Loper, Day, Smith. A system for detecting mutagens, described by Ames (Proc. Natl. Acad. Sci. 69:3128,1972), is based upon *Salmonella* mutants which require histidine for growth. These mutants are available in strains modified for increased sensitivity to a wide range of compounds.

Our current interests in the method concern:

1. Extension of the set of mutants involved (Loper). The goal is to establish a larger set of mutants each of which responds only to a particular, known base change. 2. Use of the method for characterizing compounds under study in our laboratories (Day, Smith). 3. Extension of the method to include detection of host-mediated mutagenesis in the monkey (Smith, Loper).

ENVIRONMENTAL MEDICINE-2

Session Chairman and Editor

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Biological Effects of Toxic Metals in the Environment - Renal Hg and Cd

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Biological Effects of Toxic Metals in the Environment - Neurochemical Pb and Hg

I. ARTHUR MICHAELSON, Department of Pharmacology, College of Medicine, UC

Concepts of Toxic Effects of Environmental Chemicals on Essential Metal Metabolism

HAROLD G. PETERING, Department of Environmental Health, College of Medicine, UC

Biologic Effects of Toxic Metals in the Environment - Pulmonary

KLAUS L. STEMMER, Department of Environmental Health, College of Medicine, UC

Management of Animal Colony for Toxicological Research

DAVID K. HYSELL, Veterinary Medicine and Pathology Section, Environmental Toxicology Research Laboratory (Air), NERC, EPA

Toxicology of Chemicals in Drinking Water

ROBERT G. TARDIFF, Criteria Development Branch, Water Supply Research Laboratory, NERC, EPA

Epidemiology of Pollution

LELAND J. McCABE, Criteria Development Branch, Water Supply Research Laboratory, NERC, EPA

Public Health Impact of Producing Nuclear Power

RICHARD L. BLANCHARD, Radiochemistry & Nuclear Engineering Research Laboratory, NERC, EPA

ENVIRONMENTAL MEDICINE - 2

Man is exposed to a variety of environmental pollutants, including the chemical and radioactive substances which contaminate his environment. The acute and chronic effects produced by heavy metal compounds and by certain organic and inorganic compounds need to be further defined, and toxic doses need to be determined to provide satisfactory information to establish permissible levels of these toxicants in the air and water environments. Similarly, the impact upon the environment of radionuclides derived from nuclear power and from other sources need to be determined. The stable and radioactive pollutants in the environment and their pertinent biological effects are matters of growing concern.

Foulkes. Efforts are being made to define in the rabbit the functional lesion leading to aminoaciduria in heavy metal poisoning. The aminoaciduria is well documented, but its site and nature remain unclear. The first step in the investigation was the demonstration that the process of amino acid reabsorption is primarily a function of the proximal epithelial cell membrane facing the tubular lumen (luminal membrane). It is at this site, for instance, that glutamate competitively inhibits reabsorption of filtered aspartate. Experiments with uranyl and mercury compounds then showed that the amino acid transport system on the luminal membrane is sensitive to these heavy metals. An extension of this study to cadmium-poisoned animals not only confirmed the conclusion that heavy metals inhibit amino acid transport at the luminal membrane, but further showed that this is essentially a nonspecific effect inhibiting equally reabsorption of all amino acids: amino acid clearances are uniformly raised in the absence of changes in circulating plasma levels.

A further action of heavy metals could be demonstrated on the oposite side of tubule cells, that is, on that facing peritubular interstitial spaces. Cellular uptake of amino acids, and especially of neutral and dicarboxylic compounds, could be demonstrated across the peritubular cell membrane. This process appears to constitute active transport, and occurs in a direction opposite to that of reabsorption. In the case of glutamate and aspartate, a strong inhibition by heavy metals occurred. No such effect was seen with neutral or basic amino acids. These findings indicate multiple sites of action of heavy metals at the level of proximal tubular cells.

Michaelson. Lead poisoning is characterized by a range of overt syndromes including anemia, acute abdominal colic, peripheral neuropathy, renal insufficiency, cerebral incompetence, and encephalopathy. Our interests are the central effects of this ubiquitous intoxicant. Inorganic lead produces cerebral dysfunction and clinically definable encephalopathies. At least 25 percent of those who survive acute encephalopathy from lead poisoning in early childhood have permanent CNS impairment frequently leading to a residual behavioral deficit.

The lead literature is replete with histopathological descriptive evaluations of lead encephalopathy, but to date there have been few studies on the biochemical changes in brain following exposure to inorganic lead. Such studies

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have been impeded by lack of suitable experimental models. We believe that a suitable model is now available. Brain lesions will develop in neonatal rats when a pregnant rat, newly delivered of her litter, is placed on a lead-containing diet and sucklings receive lead *via* the mother's milk. Lead intoxicated neonates display retardation in development, ataxia, paraplegia, and cerebellar vascular damage developing in the latter part of the third week of life. There is an approximate 85-fold increase (ppm, dry weight) in the lead concentration of both the cerebellum and cerebral cortex relative to controls, but edema and gross vascular changes are confined to the cerebellum. Ingested lead had little effect on RNA, DNA and protein concentrations (mg per gram, wet weight) of developing rat cerebellum and cerebral cortex. However, there is a reduction of 10 to 20 percent in the DNA content (mg per organ) of the cerebellum at about three weeks of age in the lead exposed sucklings. This suggests a failure of cell multiplication in this part of the brain.

Petering. The study of the toxicity of chemicals in the environment is complicated by the long term exposure of large populations to low levels of a multiplicity of agents. Such exposure taxes experimental conditions and forces the experimentalist to use innovative methods to obtain clues to the human situation.

Several factors are important for successful studies of environmental chemical hazards. These are nutritional control, which is imperative because nutritional factors may act as preventive agents, tobacco smoke which complicates the evaluation of the health effects of many agents on human populations, the altered toxicologic action of chemicals carried by particles, and the vulnerability of biologically essential trace metals exposed to the action of environmental chemicals.

Stemmer. Four cases of chronic cadmium pneumoconiosis were examined in which exposure to high concentrations of cadmium oxide fumes were intermittent. The events of exposure occurred over periods up to 17 years.

The pathologic findings were a diffuse marked fibrosis with atelectasis. The remaining airspaces were lined by low cuboidal epithelium. Focally, metaplasia to squamous cell epithelium was observed. The bronchial epithelium was hyperplastic. There was diffuse infiltration by lymphocytes and macrophages of varying degree.

Besides the pulmonary fibrosis, in each lung a marked perivascular fibrosis was present. In two lungs, different stages of thrombosis in the small branches of the pulmonary arteries were demonstrated. Recent mural thrombi, thrombi in organization, and old recanalized ones were present.

The concentration of cadmium in these lungs ranged from 4.3 μg per gram of wet weight to 16.1 μg per gram of wet weight. The concentration in the hair varied from 6.5 to 17.3 μg per gram.

Hysell. The Central Animal Quarters (CAQ) of the National Environmental Research Center, Cincinnati provides environmental researchers a means for assessing the biologic effects of potentially toxic materials in mammalian test systems. Organizationally, the CAQ consists of a specialized staff operating under the general administrative authority of the Director of NERC, Cincinnati. In addition, an animal care committee, composed of animal users and laboratory animal experts from within and out of government, functions in an advisory status. Animal holding areas are maintained at three

locations: R. A. Taft Laboratory, Environmental Toxicology Research Laboratory, and Northeast Water Supply Research Laboratory. The CAQ functions to provide researchers with healthy laboratory animals, to provide appropriate areas and standard equipment for housing animals, and to provide an acceptable means for disposal of experimental material no longer needed. The CAQ also provides advice to researchers on appropriate animal models, assesses the physical health status of individual animals so that their suitability for a specific research study may be determined, and evaluates husbandry conditions during experimentation which might interfere with test results. The net results to the researcher are that he is relieved of the routine animal colony management problems, secures a more uniform and better animal model and ultimately has more time to devote to his research programs.

Tardiff. The establishment of health standards, or Maximum Allowable Limits, for chemicals in drinking water requires extensive information about the toxicity of these agents in man and experimental animals. Such information falls into three categories, toxicity studies in experimental animals, clinical investigations in man, and epidemiologic studies comparing the occurrence of diseases with environmental and occupational exposures to chemicals. The Water Supply Research Laboratory at NERC, Cincinnati is conducting gross toxicity studies on aggregated organic compounds found in drinking water and biochemical toxicity studies with metals and their organic derivatives.

Organic compounds in drinking water are being concentrated and identified chemically, and the acute toxicity of the concentrated materials is being investigated. The chronic toxicity of such organic aggregates will be investigated subsequently.

The possibility that methyl mercury alters the toxicity of other foreign compounds by altering the way they are metabolized is being investigated enzymatically. Methyl mercury's effects on energy metabolism in the cerebral cortex (as measured by effects on the cytochrome chain, pyridine nucleotides, and flavoproteins active in the oxidation of glucose) are being examined in order to define minimum effects in this target organ. Investigations with cadmium are being conducted to obtain information about the biochemical lesions in the kidneys that may be associated with chronic cadmium poisoning. A tissue culture laboratory has been established to determine the effects of compounds on cell viability and genetic integrity.

McCabe. Epidemiological research is being conducted by EPA to determine the health effects on man in his contact with the water environment. Drinking water is the most intimate contact and most work concerns this exposure.

The classical epidemiological approach is being used in the investigation of waterborne disease outbreaks. This is done in cooperation with the National Center for Disease Control (NCDC) with our provision of expertise on water supply and the periodic analyses of outbreaks to determine what deficiencies of water supply practices allow the outbreaks to occur.

The endemic occurrence of disease that can be waterborne is studied to determine if water supply plays a role. This work will be combined with a survey for viruses in drinking water to determine effects on morbidity.

In cooperation with prospective studies related to air pollution, water

samples are collected from the homes of study families to relate to human body burdens of trace metals. For the metals that are included in the drinking water standards, the intake from water seems to result from corrosion of the distribution system.

Two studies have been conducted on the subclinical effects of nitrate on children to confirm the necessity for keeping the drinking water standards at the current limit. Several investigators have pointed out a relationship between soft or low mineralized water and higher cardiovascular mortality. This would seem to be a most interesting and significant problem to study.

It is the goal of the new water pollution legislation to make the waters of the nation suitable for recreation, but it is not known how clean the water must be to prevent a health risk to recreators in or on the water. An epidemiological-microbiological study has been undertaken to define health criteria for recreational water quality.

Blanchard. To determine the impact on public health of producing nuclear power, it is necessary to determine: 1. the concentration of radionuclides discharged by the nuclear plant to the surrounding environment, 2. the pathways through which the radionuclides move through the environment to man, 3. the exposure to the population resulting from the decay of the discharged radioactivity, and 4. the biological effect of the exposure.

The Radiochemistry and Nuclear Engineering Research Laboratory (R&NERL) is, at present, investigating the first three factors at typical operating nuclear power plants, and developing a program that can be utilized by power companies to provide this information in an efficient and routine manner. These studies will be expanded to include nuclear fuel reprocessing plants. The release of radioactivity from boiling water reactors results in annual exposures to some nearby persons of 25-30 mR from the plume and a few mR from eating fish and drinking water. At a pressurized water reactor, the exposures are lower. A fraction of an mR is received from consuming fish and about 2 mR from external radiation from the plume and from the reactor and on-site storage.

Included also in the R&NERL program is the development of methods to measure low concentrations of radionuclides in air, water, and environmental samples. We have not attempted to study the biological effect of low-levels of radioactivity on man. Effects studies have been in progress at other laboratories for a number of years, but these studies are complex and require extended periods, hence definitive answers are not yet available.

Other aspects to be considered include the evaluation of benefit vs. risk from nuclear power, and of the relative hazards from various sources of power. Attempts at such evaluations are currently at very elementary levels.

MATHEMATICS

Session Chairman and Editor

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Management Science in Solid Waste

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Optimization of Solid Waste Collection Systems

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Quantitative Technics in Solid Waste Management

DANIEL G. GREATHOUSE, Systems Management Branch, Office of Solid Waste Management Programs, EPA

Survey of Some Statistical Technics in Research

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Sampling Strategies and Interpretation of Data

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MATHEMATICS

Mathematical and other quantitative technics apply to problems in pollution and solid waste disposal. These technics range from the statistical, such as analysis of variance, partial correlation coefficients, and stepwise multiple regression to optimization procedures in the management of solid wastes. The tools of linear programming, scheduling, and nomograms must be applied resourcefully in the solutions of these problems.

Klee. Solid waste management science research sponsored by the EPA has been conducted in the areas of districting and routing, facilities location, measures of effectiveness, and evaluation of competing alternatives.

Districting and routing involve assigning areas of a municipality to be collected on a route to trucks and then ordering them in the most efficient manner. Management science approaches investigated include assignment problem, Chinese postman problem, truck dispatching problem, and variations of the political districting problem. The size of most real-world collection/districting problems dictates the use of computer-based heuristic algorithms for their solution, although simulation is sometimes of value.

Facilities location refers to the optimal selection from sites already in existence, or alternatively, the optimal location of new sites, for the location of landfills, incinerators, garages, transfer stations, or other solid waste facilities. Linear programming, locational equilibrium, and fixed-charge models have been used in this context. Heuristic technics for solving the fixed-charge problem have been shown to be reasonable solutions to locational problems, but the existence of local optima presents difficulties.

To either evaluate or optimize a solid waste storage, collection, and transportation system, the significant variables that reflect upon the performance of the system must be identified, quantified, and combined by some model to produce one or more measures of effectiveness. Such models must describe a multidimensional utility function, because simple response variables such as cost and time are not adequate for the description of complex man-machine systems. For this purpose, certain psychometric scoring models, such as conjunctive and disjunctive, are currently under investigation.

Finally, EPA, the consulting firms under contract to it, and the recipients of the grants that it administers, are presently engaged in a broad program of research and feasibility studies in a campaign to attack the pressing problems of solid waste storage, collection, transportation, and disposal, as well as pollution and health hazards arising from solid waste related activities. These studies are usually discharged with an evaluation of the competing alternatives proposed to solve a specific problem. Such evaluation then serves as a basis for planning and strategy formation in a particular problem area. Unfortunately, it is not always clear: 1. what factors are used to evaluate these alternatives, 2. what is the evaluator's view of the importance of the factors, or 3. what is the worth of each alternative with respect to each factor. To introduce a rational, orderly process for the scoring of alternatives, EPA is examining the general category of decision weighting models to develop viable technics for making its decisions, and to study the inputs needed to utilize such models effectively.

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Shupe. Almost a ton of solid waste will be collected in our cities this year for every man, woman, and child in the United States. The cost of this municipal collection will be approximately five billion dollars, or one-half percent of the GNP.

In recent studies with municipalities in Greater Cincinnati to quantify the time required for residential collection of cans and bags using the load packer truck, we have used technics involving multiple regression analysis of historical collection data by collection area (City of Cincinnati), prediction of collection time by collection area (City of Cincinnati), and prediction of collection time by block face (City of Covington, Kentucky).

The historical regression analysis when applied to recorded data for forty of Cincinnati's collection areas, establishes a correlation between collection times and the variables number of trucks, stops, dwelling units, tons, and distance to the disposal site.

The time predictive model (by collection area) assumes that the total work for an area is shared equally by the truck/crews serving that area. The collection process is divided into work elements (for example, travel between stops) with time-predictive equations developed for each element. The results are useful for balancing collection assignments.

A predictive model by block face, again utilizing work elements, is now being developed for the City of Covington. The results of a detailed eight-week field survey provide a data bank encompassing every collection stop in the city. The block face approach can be utilized to accurately predict the collection time for any defined route and method of collection.

Greathouse. The Office of Solid Waste Management Programs, NERC, Cincinnati, has the responsibility for providing technical assistance to other federal, state, and local solid waste agencies. This involves the development and implementation of quantitative technics in determination of solid waste generation quantities and characteristics produced by source type, evaluation of existing practices and identification of alternatives, measurement of direction and magnitude of change, design of experiments and analysis of results.

Determination of solid waste generation quantities and characteristics produced by source type requires the identification of source types (residential, commercial, industrial, for example) and the design of a study that will yield the desired information. Technics that have been investigated include survey sampling, multiple regression analysis, and experimental design. The area (local and regional, state, or national) of interest and the reliability and accuracy desired, dictates the particular technics used.

To effectively evaluate existing practices or identify alternatives, it is first necessary to define the problem to be studied and identify those factors which affect the problem. This definition and identification stage is followed by the actual study. An example of a major effort in this area was the fulfillment of a mandate by Congress to determine the present level of manpower, the future training needs, and the obstacles for advancement in the solid waste management organizations throughout the country. This study alone involved extensive use of survey sampling, opinion survey technics, and other quantitative methods.

Measurement of direction and magnitude of change implies the determination of the relevant factors which are measures of change and the

identification of descriptors to quantify the changes in the factors. Examples of these types of studies are evaluation of the effectiveness of public education programs, determination of the effect of changes in solid waste operating procedures, and measurement of the success of national programs to improve solid waste practices.

The primary uses of design of experiments and the resultant analysis of results has been in the measurement of the physical, biological, and chemical properties of solid waste, and the determination of those factors which affect these properties. The results of these studies have been important to the federal solid waste research program.

Chang. Statistics play an important role in research. Analysis of variance is one of the more important statistical technics used in research. Its purpose is to search for conditions and features of an experimental design to which variation can be ascribed. For example, a test may be performed to compare four kinds of gasolines in which three test runs are undertaken with a gallon of each kind.

The null hypothesis tested may be that all gasolines give the same mileage. If different test cars do not contribute variation, then a one-way analysis of variance model should be used. Otherwise, a two-way analysis model or a factorial design, must be used.

Even in such a simple example different models may lead to different conclusions.

Another useful statistical technic which experimenters often neglect is the partial correlation study. Its purpose is to examine the interrelation of several variables. For example, in an experiment by Hooker in 1907, the relations among yields of hays, rainfall, and temperature, were studied. With simple correlations, yield and rainfall were positively related, and rainfall and temperature were negatively related. But what interpretation was to be given to the negative relation between yield and temperature? To answer this question, the partial correlation between yield and temperature was computed and found positive. So the conclusion was that both high rainfall and high temperature increased hay yield, but that in most years high rainfall occurred with low temperature, and vice versa.

Since the development of the high speed computer, the multiple regression method has become a most popular statistical technic, and the stepwise regression procedure one of the best ways for selecting the best regression equation.

Saltzman. Monitoring of pollutants involves handling many samples and expenditure of much time and money. Careful advance planning and efficient utilization of the information obtained are therefore important. Simplified nomograms applicable to both normal and lognormal distributions are available for relating numbers of samples to confidence intervals, and for determining the proportion of the population exceeding a specified concentration. Sampling program design must also include quality control.

The choice of sampling time affects the observed results because of attenuation of the more rapid fluctuations. Transmittance of the *sampling window* is a function of the ratio of fluctuation period to sampling time. A corresponding plot for the transmittance of the *biological window* may be presented in terms of a parameter including the biological half-life of the

pollutant.

Fourier analysis by computation of air pollutant data allows plots of amplitude vs. fluctuation period. These characteristic spectra are analogous to spectra obtained when colored light is passed into a spectroscope. The calculations should aid in theoretical understanding and design of sampling programs.

MICROBIOLOGY

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Indicator Organisms

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Pseudomonas in the Hospital Environment

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Bacterial Criteria for Water Quality

EDWIN E. GELDREICH, Standards Attainment Branch, Water Supply Research Laboratory, NERC, EPA

Disinfection of Waters and Wastewaters

RILEY N. KINMAN, Department of Civil and Environmental Engineering, College of Engineering, UC

Virology of Water and Solid Wastes

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Inactivation of Animal Viruses in Water

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Pathogenic Protozoa in Water

SHIH LU CHANG, Etiology Criteria Development Branch, Water Supply Research Laboratory, NERC, EPA

Microbiologically-Induced Metallurgical Corrosion

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MICROBIOLOGY

More zealous research and monitoring efforts are essential to insure the microbiological safety of waters and particularly the reliability of water and wastewater treatment practices. Microbiological data on sewage disposal practices and disinfection technology are badly needed as is information on the adequacy of current technology in the routine monitoring for pathogens in water. Routine detection methodology has yet to be established for waterborne viruses of human origin.

Kenner. The public water supplies of the 100 largest cities in the United States furnish 9,650 mgd of water to 60 million people, which is approximately 30 percent of the nation's total population and 48 percent of the urban population. About 80 percent of the supplies we have tested contained *Pseudomonas aeruginosa*, only 25 percent contained fecal coliforms, 45 percent contained fecal streptococci, and 9 percent contained *Salmonella* species. While developing a membrane filter method for determining total aerobic mesophilic counts, we found that waters (with no detectable chlorine) containing four or more cytochrome-oxidase negative bacteria per 100 ml also contained *Ps. aeruginosa*. In a 10 gallon test that we devised, waters containing two or less cytochrome-oxidase negative bacteria per 100 ml contained no *Ps. aeruginosa*.

A recent study at the Baltimore Cancer Research Center of the National Cancer Institute showed that 8.1 percent of 557 hospitalized patients developed *Ps aeruginosa* bacteremia. Hospital staff cultured the organism from hospital water faucets that had no aerators.

According to Standard Methods for the Examination of Water and Waste-water, 13th Edition (APHA, AWWA, AND WPCF), the bacterial indicators of pollution are the coliform group. However, rigid adherence to a single indicator can lead to false assuredness of the biological safety of water. Clearly, we must look to overhauling our indicator systems. In times of growing populations and crowding conditions, tradition is a poor reason for relying on indicator systems that growing evidence suggests are inadequate.

Maley. Pseudomonas aeruginosa is widespread in the environment. This organism has been cultured from water, food, cosmetics, medicinals and from a variety of other sources. Its presence in the burn hospital environment presents a potentially serious source of patient infection.

A variety of methods is employed to evaluate the hospital environment microbiologically. Fixed volume air samplers and sediment plates determine the presence and quantity of pathogens in the air. Various contact methods and swabs are used to collect samples from floors, walls, counter tops, and other surfaces. Cultures are obtained from hands and hair on contact (impression) plates, and from the nose by nasopharyngeal swabs.

Sinks, aerators, burn tubs, and equipment water supplies have frequently contained *Pseudomonas*. Disinfectants and sterilizing agents have been studied for control of these pathogens. Clothing worn by personnel when on the ward

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and working with patients has been controlled and studied. The air, although presently not involved in *Pseudomonas* transmission, is also controlled and monitored. The result of these efforts has been the reduction or elimination of potential sources of *Pseudomonas* infection in burn patients.

Geldreich. Bacterial criteria for water quality must be based on parameters that relate primarily to health hazards. Other considerations may include bacterial criteria for adequacy of water supply treatment and taste, odor, or spoilage indicators in products produced by food, beverage, cosmetic and drug industries. Disease-causing bacteria, viruses, protozoan worms, and fungi are found in water polluted with the wastes of man and other animals. However, the occurrence and density of pathogens in polluted waters and animal feces are highly variable. Unfortunately, there is no single test that will adequately detect and quantitate the wide spectrum of these pathogenic occurrences. Therefore, an indirect approach to microbial hazard measurement is required, based on the use of a bacterial indicator system that will detect and quantitate fecal pollution from all warm-blooded animals. For this reason, major emphasis has been placed on fecal coliform measurements. Any occurrence of fecal coliforms in water is prime evidence of contamination from some warm-blooded animal waste discharge. As the fecal coliform densities increase, the potential health hazards become more prevalent and the challenge to a wastewater treatment barrier more demanding. The total coliform group is considered the primary indicator of the adequacy of potable water supply treatment and protection during transmission through the distribution network. However, the general bacterial population (as measured by the Standard Plate Count) in drinking water must be controlled to avoid increased risk of exposure to secondary pathogenic invaders and an undesirable suppression of low density coliform occurrences.

Standards for bacterial criteria (maximum permissable density limits), established by government authority, must be supported by state-of-the-art scientific knowledge, attained through advanced technology and tempered by socioeconomic considerations. Modifying these standards merely to accommodate poor quality streams or estuarine waters that require pollution abatement repudiates the philosophy of water quality enhancement.

Kinman. Disinfection of waters and wastewaters constitutesthe primary means for protecting the general population from disease-producing organisms. Water and wastewater disinfection are complex processes. Temperature, pH, contact time, organisms involved, type of disinfectant, and disinfectant concentration are some of the important factors affecting the degree of disinfection achieved. Although much information is available on disinfectants and on their successful application, much more information remains to be developed especially on disinfection of waste waters contaminated by viruses and destined for direct reuse application.

A large number of chemical disinfectants have been tested both successfully and unsuccessfully for various water applications. At present, chlorine is the principal agent in use despite limitations in its efficiency in some situations. There is no single perfect disinfectant, but chlorine currently offers a better overall efficiency than any other chemical.

In the Department of Civil and Environmental Engineering, we have been examining chlorine and chlorine compounds in natural and polluted systems

for use against bacteria and viruses. We have studied iodine and various methods for releasing iodine in potable and non-potable applications. We have also studied mixtures of halogens and ozone.

In addition to disinfection efficiency, study has been directed to development of analytical methodology for determining and monitoring low levels of chemical species in water. A new analytical method for ozone in water has been developed and a continuous chemical monitor for virus studies is under development.

Berg. More than 100 different viruses are excreted by man and discharged into waterways as a result of inadequate waste treatment practices. Because they do not multiply outside of susceptible living hosts, viruses diminish in numbers in the relatively hostile environment of sewage, surface waters, and solid wastes. Because they can produce infections when ingested in very small numbers, they are important in the smallest amounts that can be detected.

To detect small quantities of viruses, methods must be developed that are capable of recovering viruses from relatively large volumes of water and solids. Our present goal is to detect one virus particle in 100 gallons of water. No goal has been set for solid wastes. We have already developed technology capable of this efficiency with distilled water by adsorbing viruses onto cellulose nitrate membranes through which the water is filtered and eluting the viruses from the membranes. This technic is much less effective with sewage or surface waters, because these contain organics that interfere with adsorption of viruses. In the last few years, we have found that more virus adsorbs to the solids in water than we find in the waters themselves. The efficiency of our methods for recovering viruses from solids is very low, however. We therefore labor to develop better methods for recovering viruses from water and the solids in water.

Methods also need to be developed for removing and destroying viruses in sewage and other waters and in solid wastes that contain them. Thus waste and water treatment procedures must be evaluated for their virus removal capability, and disinfection procedures need to be developed that are capable of destroying all viruses in waste and other waters and in other environmental wastes.

Scarpino. Literature on water chlorination is often equivocal because standard conditions for testing were not used. Often the literature lacks information on the chemical conditions in the test systems, and on the types of chlorine present in the chlorinated water.

Since sewage-contaminated water is a potential health hazard, an awareness of the efficiency of applied disinfectants on human enteric pathogens is important. This is particularly true with viruses which are considerably more resistant to the environment than bacteria.

Disinfectants should be chosen to meet particular needs. To determine which disinfectant species is best suited to meet each specific need, disinfectants must be tested under essentially identical conditions. Thus, our research is a continuing part of the cooperative comparative disinfection study coordinated by the Virology Program at the National Environmental Research Center, Cincinnati.

Comparisons were made between the inactivation rates at 5 C of viruses and bacteria in chlorinated phosphate buffer systems at pH 6 (HOCl), and in

chlorinated borate buffer systems at pH 10 (OCl^-). Coliforms and coliphages were investigated to determine their value as indicators of animal virus pollution of chlorinated water.

A log-log plot of the relationship of chlorine concentration (as HOCl or OCl^-) to time for 99 percent inactivation of the test microbes showed that slopes approximated 1, indicating similar first order inactivation mechanisms. At pH 6, the animal viruses (poliovirus 1 and coxsackievirus A9) were the most resistant, being 13 times more resistant than the RNA coliphages f2 and MS2 (which were equally sensitive), about 40 times more resistant than *Escherichia coli* and about 135 times more resistant than the DNA coliphage T_5. At pH 10, *E. coli* was most resistant being about twice as resistant as the animal viruses, about eight times as resistant as T_5, and 10 times as resistant as f2.

Chang. Attention on waterborne protozoan infections has shifted in the past decade or so from amoebiasis to giardiasis. Small outbreaks in the ski resort area near Denver, Colorado were reportedly associated with contamination of wells by sewage. Cases in Boulder, Colorado believed waterborne, extended into a small Iowa town where water is supplied by wells. We have been involved in developing methods for examining large volumes of water for *Giardia* cysts.

The etiology of primary amoebic meningoencephalitis has been of two types, *Acanthamoeba* and pathogenic *Naegleria*. Pathogenic *Naegleria* invade the cranial cavity directly through the cribiform plate and subjacent nasal mucosa and cause death in five days. In the USA, small warm lakes and a warm spring-fed pool have been sites of infection.

In the research of this disease the most pressing task is to determine the incidence and source of the pathogenic *Naegleria* in surface waters.

Research in our laboratory indicates that the pathogenic *Naegleria* is more likely a parasite than a free-living form.

Acanthamoeba brain infection occurs in defense-weakened patients. The amoeba is believed to use the blood stream as a portal of entry. All strains of *A. rhysodes* are weakly pathogenic.

Tholke. It is normal for metals to react with their surrounding medium and reassume a chemically combined form. This is metallic corrosion. Many years of studying and observing the corrosion processes has led to a categorization by types which are readily indentifiable and at the same time implies a corrosion mechanism or cause for the corrosion. These types are listed as follows: 1. general or uniform attack, 2. pitting, 3. galvanic or two-metal, 4. selective leaching - "dezincification", 5. intergranular, 6. "crevice" or "concentration cell", 7. stress-corrosion, and 8. erosion-corrosion.

Much of the corrosion of metals occurs in the presence of moisture, in aqueous or electrically conducting mediums. Under these circumstances, the corrosion reaction becomes electrochemical in nature with separate anode and cathode reactions. Frequently, when metals are used in underground or cross-country applications and structures, they encounter mediums conducive to microorganism growth. In these instances, the microorganism growth and metabolic process may have a very deleterious effect on the metallic corrosion rates.

Two types of microbes are commonly recognized and associated with the corrosion processes. Certain aerobic bacteria convert sulfur and sulfur-bearing

compounds to sulfuric acid and materially increase corrosion reaction rates. Certain anaerobic bacteria reduce soluble sulfates to sulfides and in the process actively depolarize and speed up the cathode corrosion reaction, hence speeding up the corrosion process. Both of these microbiological processes must be recognized and adjustments made for them in the wise selection and usage of metals where these conditions are encountered.

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